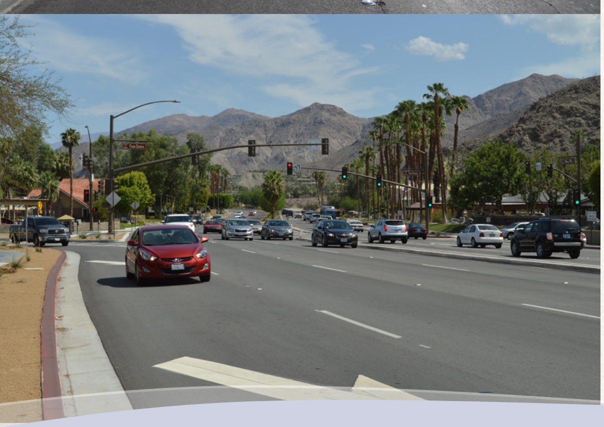
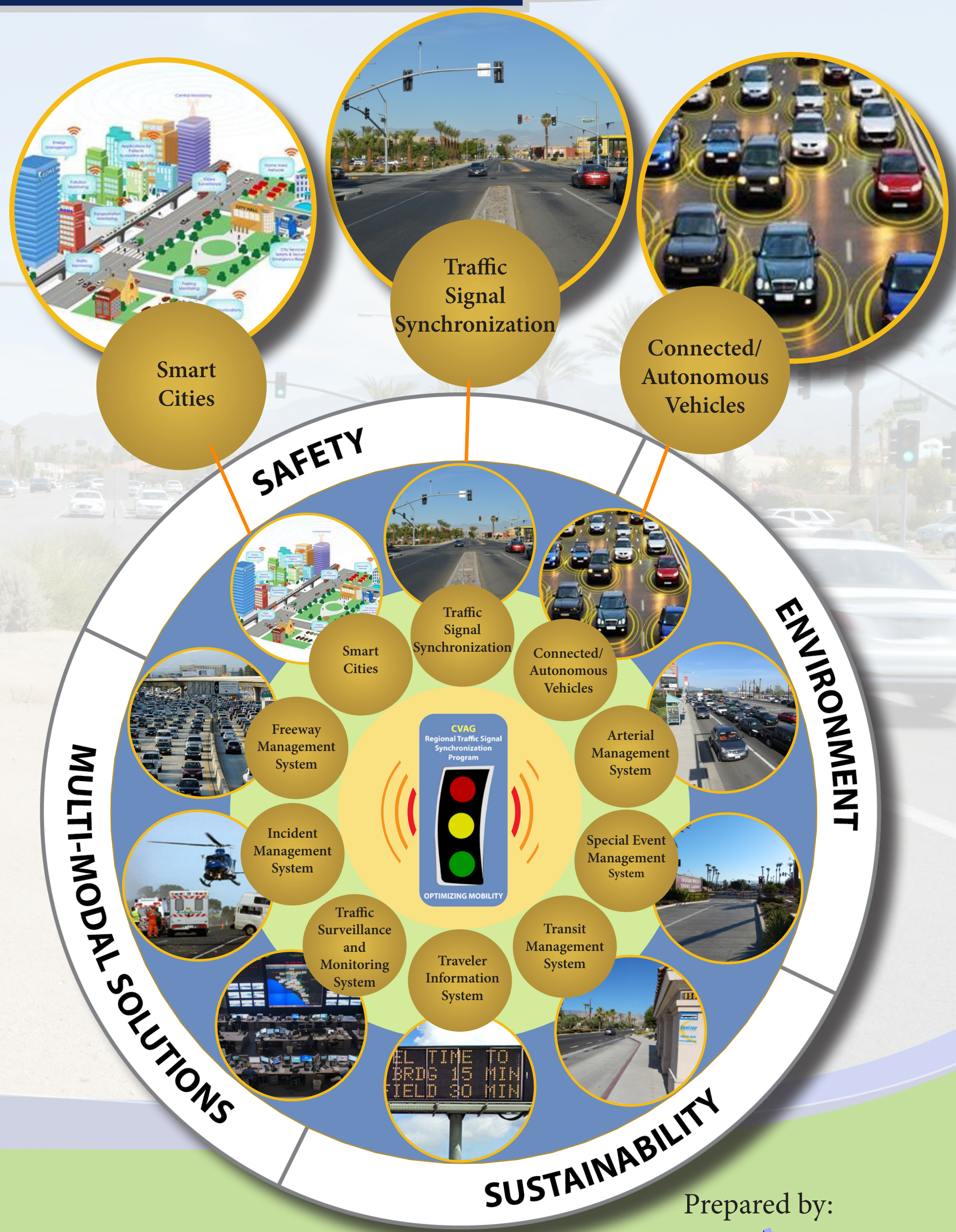
CVAG
Regional Traffic Signal Synchronization Program
OPTIMIZING MOBILITY

COACHELLA VALLEY ASSOCIATION OF GOVERNMENTS (CVAG)
REGIONAL TRAFFIC SIGNAL SYNCHRONIZATION PROJECT

# TRAFFIC SIGNAL INTERCONNECT MASTER PLAN

## INTER-AGENCY COMMUNICATION NEEDS






Prepared for:

Coachella Valley Association of Governments
CVAG

Prepared by:

ADVANTEC
Consulting Engineers

## COACHELLA VALLEY ASSOCIATION OF GOVERNMENTS (CVAG)

## REGIONAL TRAFFIC SIGNAL SYNCHRONIZATION PROJECT

# *TRAFFIC SIGNAL INTERCONNECT MASTER PLAN*

## Inter-Agency Communication Needs

*Prepared for:*

**Coachella Valley Association of Governments (CVAG)**

Prepared by:

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1200 Roosevelt
Irvine, CA 92620

October 24, 2017

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## Inter-Agency Communication Needs


Prepared By

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**October 24, 2017**

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| Version | Date | Author/ QA/QC | Comment |
|---|---|---|---|
| 1.0 | 10/24/2017 | John C. / John D. / Carlos O. | For Distribution |
| | | | |
| | | | |

## Project Website

An electronic copy of this report can be found at: http://cvag-regionaltssp.com/

## ACKNOWLEDGMENTS

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## LIST OF ACRONYMS

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ATC | Advanced Transportation Controller |
| ATMS | Advanced Traffic Management System |
| C2C | Center-to-Center communications |
| C2F | Center-to-Field communications |
| CAD | Computer Aided Dispatch |
| Caltrans | California State Department of Transportation |
| CCTV | Closed-Circuit Television |
| CMS | Changeable Message Sign |
| DAC | Data Aggregation Center |
| DOT | Department of Transportation |
| DSRC | Dedicated Short Range Communication |
| EAS | Ethernet Access Switch |
| FHWA | Federal Highway Administration |
| GHG | Greenhouse Gas |
| ICM | Integrated Corridor Management |
| IP | Internet Protocol |
| IT | Information Technology |
| IoT | Internet of Things |
| ITE | Institute of Transportation Engineers |
| ITS | Intelligent Transportation Systems |
| MAP-21 | Moving Ahead for Progress in the 21st Century Act |
| MOU | Memorandum of Understanding |
| MPAH | Master Plan of Arterial Highways |
| NEMA | National Electrical Manufacturers Association |
| NTCIP | National Transportation Communications for ITS Protocol |
| SDP | Strategic Deployment Plan |
| SR | State Route |
| TMC | Traffic Management Center |
| TMS | Traffic Management System |
| TSS | Traffic Signal Synchronization |
| V2I | Connected Vehicle to Infrastructure |
| V2V | Connected Vehicle to Vehicle |
| V2X | Connected Vehicle to Everything |
| VMS | Video Management System |

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## 7-1. Introduction

This section identifies communication needs for inter-agency coordination via a region wide basis for establishing needs of communication between adjacent cities, the Coachella Valley Association of Governments (CVAG), County of Riverside, and Caltrans District 8. A framework is provided for inter-agency coordination to provide a common structure for the planning, design, deployment, management, operations and maintenance of current and future Advanced Traffic Management Systems (ATMS), Intelligent Transportation Systems (ITS), and communication systems. This includes preparing the region for the future Connected and Automated Vehicles (CV/AV), Integrated Corridor Management (ICM), mobile applications, and SMART Cities.

The inter-agency coordination for these project deployments include, but not limited to, sharing traffic data, signal coordination, High Definition (HD) Internet Protocol (IP) Closed Circuit Television (CCTV) video images, traveler information systems, arterial and freeway management systems, transit priority systems (such as bus rapid transit), inclement weather messages, and dynamic/changeable message sign messages. This project provides the first opportunity for the Coachella Valley to implement inter-agency communication for traffic management purposes.

To accomplish this key goal, a standards-based approach can assist system applications, regardless of operating system or programming language, to communicate using simple encoded messages that both applications understand. Specifically, the objective related to the development of inter-agency communication is to establish a Center-to-Center (C2C) XML-based standard to support the two-way transmission of traffic data information, video images, and/or control commands between Traffic Management Center (TMC) systems, Data Aggregated Centers (DAG), and TMC sub-systems.

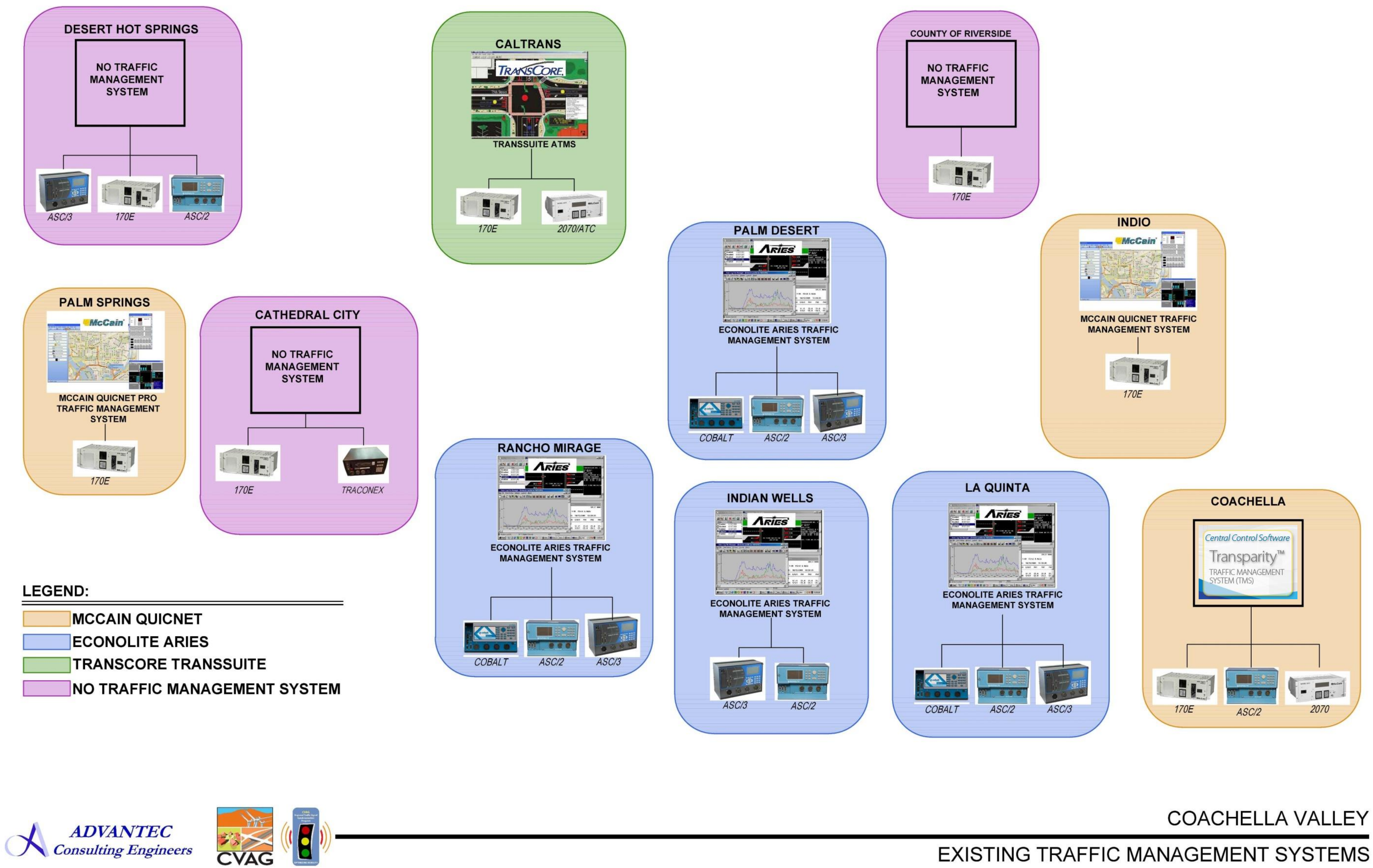
## 7-2. System Area

The study area consists of analyzing the local cities/agencies traffic management systems, communication systems, and intelligent transportation systems (ITS) within the Coachella Valley.

**Figure 7.1** illustrates the existing traffic management system per agency. This includes Caltrans District 8 and the County of Riverside.

**Inter-Agency Communication Needs**

**Figure 7.1 Existing Regional Traffic Management Systems**



## 7-3. Existing Conditions

Prior to the development of new Advanced Traffic Management Systems (ATMS) and sub-systems, it is important to note the existing traffic management systems (TMS) within the Coachella Valley are legacy systems that consist of: Econolite ARIES TMS and McCain QuicNet TMS. The agencies with the up-to-date ATMS include the City of Coachella with McCain's Transparity ATMS in the City of Coachella, and Caltrans with TransCore's TransSuite ATMS. It should also be noted that the cities of Cathedral City, Desert Hot Springs, and the County of Riverside does not have a centralized TMS.

Generally, these systems are independently owned, operated and maintained by each agency, without communications or connectivity to share information to an adjacent agency or across jurisdictional boundaries. Aside from the institutional factors, there are physical and technological limitations and capabilities of these existing TMS that needs to be understood including:

- Legacy type TMS and communication systems are considered outdated and have limited to no capabilities to communicate with other systems
- Propriety TMS and traffic signal controller protocol (Legacy Econolite and McCain Systems)
- Agencies that do not have central traffic control systems
- No physical or wireless communications or connections
- Geographic location where each central system is housed

In developing a regional network, and having the capability share data and video across jurisdictional boundaries, it is important to understand what technologies are available, how they work together, and which can be used in our toolbox when considering upgrades. Therefore, the proposed Phase I upgrades include deployment of new central ATMS, Traffic Management Centers (TMC), Data Aggregate Centers (DAC), Advanced Transportation Controller (ATC) specifications, Ethernet/IP-based communications network, and closing communication gaps for each agency.

In addition, other ITS improvements should also be considered such as high definition (HD) internet protocol (IP) closed-circuit television (CCTV) camera systems, hybrid video/radar detection systems, arterial management system technologies, etc. to facilitate the operations and management of the signalized intersections and corridors; and to provide performance measurement tools to pro-actively monitor, manage, and improve the transportation system in the Coachella Valley.

## 7-4. Multi-Agency Participating Agreement

Typically, prior to the beginning of Inter-Agency or Center-to-Center improvements, the adjoining cities or agencies involved will have initiated and executed a "Participating Agreement" between all joint agencies. The Participating Agreement serves to document and provide an understanding of the role and responsibility each agency plays in ownership and sharing of traffic data and video between agencies. Currently, the draft Participating Agreement is under development and it is anticipated that it will be finalized by the end of year 2017. In general, the participating agencies roles are as follows:

**Responsibilities of Lead Agency**

- To fund, plan, design, implement, operate, maintain and manage the program.
- To provide funding for procurement and maintenance of hardware and software necessary for signal synchronization, including ITS elements, Local TMCs, DACs, and a Regional TMC.

**Responsibilities of Participating Agencies**

- To partner with Lead Agency and Participating Agencies to promote and demonstrate their commitment for inter-agency traffic signal synchronization, intelligent transportation systems, and integration of connected/autonomous/automated vehicles, and smart cities technologies.
- To provide a technical representative to meet and participate as a member of the program's Transportation Systems Management and Operations (TSM&O) Sub-Committee.
- To maintain full control of operations and maintenance of their traffic signals, including traffic signal controllers, ITS technologies and traffic signal communications. Traffic signal timing, ITS technologies, and traffic signal communications revisions, replacement and/or upgrades shall be coordinated and approved by the TSM&O Sub-Committee prior to making revisions and/or upgrades.

**Transportation Systems Management and Operations (TSM&O) Committee**

- At the end of the Regional TSSP Phase I improvement project, an effective operations and maintenance of ITS elements plan must be implemented to handle traffic systems and sub-systems at the Local, Sub-Regional and Regional level.

  As part of the Participating Agreement, a Transportation Systems Management and Operations (TSM&O) Committee that will report to CVAG's Transportation Technical Advisory Sub-Committee. The purpose of the TSM&O Sub-Committee is to develop minimum equipment standards (hardware and software), and define responsibilities and procedures to manage, procure, implement, maintain, upgrade, and operate Coachella Valley intelligent transportation systems including inter-agency signal synchronization, arterial management systems, special events management systems, integrated corridor management systems, and ITS technologies; and to develop, oversee, manage, maintain, and update the Regional Traffic Signal Synchronization Operations and Maintenance Manual.

It is anticipated that the final "Participating Agreement" will be signed and executed between all stakeholders in the valley prior to deployment of the regional traffic management, communication, and ITS upgrades.

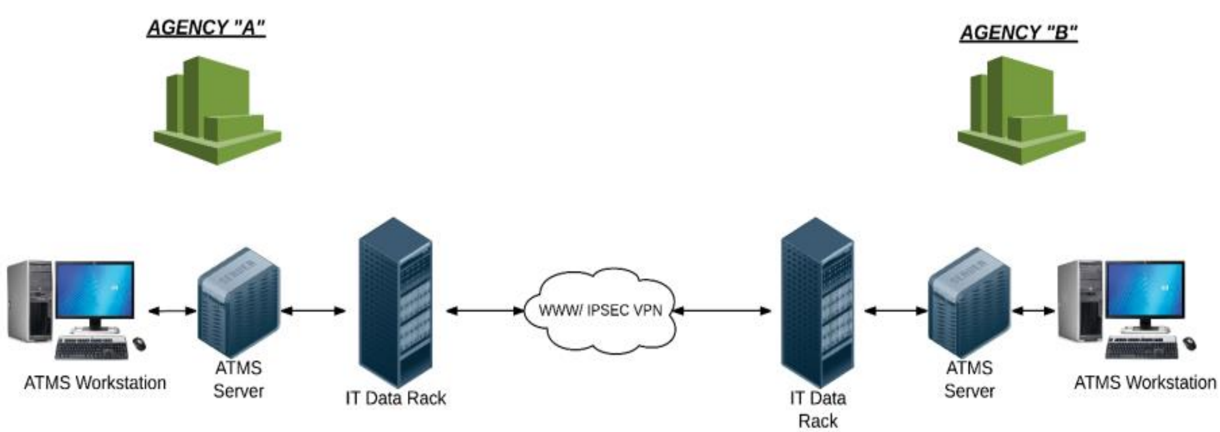
## 7-5. CONCEPT OF OPERATIONS

Center-to-Center (C2C) communications is an important objective of the Coachella Valley regional traffic signal synchronization project. The goal is to provide shared two-way traffic data and HD IP CCTV video feeds across jurisdictional boundaries. C2C communications shall be implemented through the planning process and agreements shall be established to maintain the physical connection including the use of traffic data and video feeds. For agencies that are not physically able to connect to a shared fiber optic backbone network, other connections may be established such as an IPSec virtual private network (VPN) link through the world-wide web. In addition, a third party or Consultant can be connected to the system via an IPSec VPN link to assist agencies on the operations and maintenance of the synchronized corridors.

Moving forward with inter-agency coordination will require a common communications standard. Most transportation systems have a history of containing unique data definitions and proprietary communications protocols. Field devices and systems from one manufacturer or developer were not interoperable with those of other manufacturers or developers. However, the National Transportation Communications for Intelligent Transportation System (ITS) Protocol (NTCIP) defines a common communication protocol and the Traffic Management Data Dictionary (TMDD) provides a set of standards for data definitions and open protocols that allow for future expansion of the system to benefit from true competitive bidding. The agency purchasing equipment from a specific vendor is not required to continue to purchase from the same vendor in order to maintain a functioning system. NTCIP promotes interagency coordination and communications by making devices provided by different vendors interoperable. Multiple center systems and field devices of different brands can exchange information for traffic management purposes.

Inter-agency communication can be provided in different standard forms and through several types of technologies. Standards have been created to facilitate interoperability between infrastructure components including traffic signal controllers, HD IP CCTV cameras, ramp metering systems, changeable message signs, and traffic management centers. **Figure 7.2** below depicts a typical center-to-center ATMS layout.

**Figure 7.2 Center-to-Center ATMS Interconnection**



### 7-5.1. General

Center-to-Center (C2C) communications is an important factor when determining design and deployment of a traffic management center(s) where the goal is to provide shared two-way traffic data, HD IP CCTV video streams and other traffic information across jurisdictional boundaries. Using NTCIP compliant protocols and standardized definition database such as Traffic Management Data Dictionary (TMDD), C2C communications and Inter-Agency coordination can be achieved.

To achieve this goal of each agency sharing traffic and/or video information from center-to-center, it is anticipated the center-to-field communications will be online and maintained by the owning agency. For this purpose, only the core communication equipment and protocols will be discussed here. The hardware required for this implementation mainly consists of the following:

- **Core Network Switch/Router:** Layer 3 capable Ethernet switch /router.
  - **Function:** Transcodes traffic network information. Also, links similar Layer 3 device(s) by using preferred Interior Gateway Protocol (IGP) or Static Route.
- **ATMS Server:** Commercial database hardware server.
  - **Function:** Interface to ITS roadside elements. Supplies configuration/data information. Transcodes traffic data using NTCIP protocols for information exchange.
- **Firewall/ VPN Appliance:** Security appliance.
  - **Function:** Implements standardized security functions, such as Access Control Lists (ACLs) to segment and route data packets. Also supplies VPN interface to link other remote VPN sites.

In addition to the required hardware to implement C2C communications, further software and integration will be required to implement C2C communications. In general, the following software/ protocols will be required across all traffic ATMS and video vendors:

- **Information Level:** TMDD Standard Version 3.03 (or latest edition). Provides a standard for all messages/data for all systems to exchange information.
- **Application Level:** NTCIP 2306 / XML Profile. Communications interface in which TMDD messages can be delivered/acknowledged.
- **Transport Level:** TCP/IP Standard. IEEE standard for Ethernet IP communications.

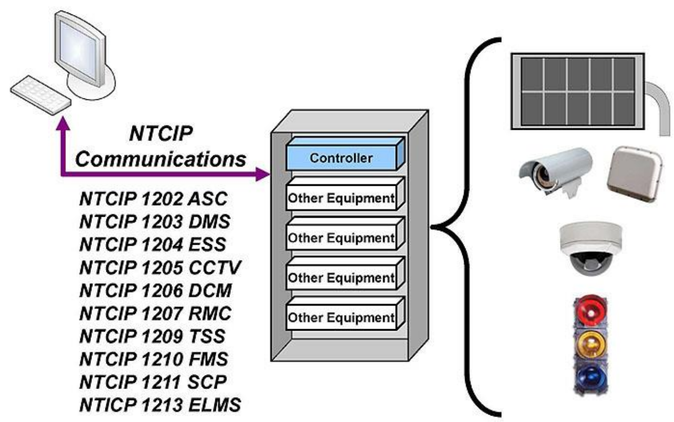
As technology advances, further research and development may be required across separate agency vendors/systems to provide for true C2C communications beyond the standards listed above. Usually attributed to “integration” work, additional resources and funding may be required to accomplish this task.

The first step in establishing C2C communications is identifying center-to-center intertie points. For instance, locations along city boundaries with shared fiber optics can provide for a high-bandwidth connection to each TMC for shared traffic data and video images using a dedicated fiber optic backbone, such as Highway 111. A fiber sharing plan should be established, with dedicated fiber strands physically connecting to each TMC.

Other types of connections between centers, such as site-to-site VPN, could provide general traffic data transfer, however, would probably not support multiple streaming CCTV images as these are much more data intensive. NTCIP compliancy and ONVIF standards dictate all modern ATMS and CCTV should be able to interface with separate nodes from a different manufacturer (i.e. Econolite to McCain) however more investigation needs to be performed when identifying exactly what messages and data flags are sent through NTCIP/TMDD/AB3418, either locally from Center-to-Field or Center-to-Center. Different manufacturer's often use different protocols for communication, therefore a thorough review will be performed during the design phase of the project to identify potential C2C communications and uplinks from sub-regional /Data Aggregation Centers (DAC), to a regional TMC (RTMC).

### 7-5.2. NTCIP Protocol

The National Transportation Communications for ITS Protocol (NTCIP) family of standards defines protocols and profiles that are open, consensus-based data communications standards. When used for remote control of roadside and other transportation management devices, NTCIP-based devices and software can help achieve interoperability and interchangeability. When used between transportation and emergency management centers, NTCIP standards facilitate agency coordination and information sharing.




The transportation industry has had a history of deploying systems with unique data definitions and proprietary communications protocols. Field devices and systems from one manufacturer or developer were not interoperable with those of other manufacturers or developers. As a result, expansion of the system after initial deployment can generally only be done using equipment of the same type and usually the same brand as in the initial deployment, unless there are investments in major systems integration efforts.

With proprietary protocols, there is little to no opportunity for realistic competitive bidding as additional field devices are added to the system, due to the lack of interchangeability. Nor, is there any opportunity for realistic competitive bidding to add additional types of field devices to the system, due to the lack of interoperability.

The NTCIP standards define common data definitions and open protocols. The proper use of NTCIP open-standards in an ITS deployment allows future expansion of the system to benefit from true competitive bidding, as well as allowing other types of field devices to be added. NTCIP is an entire family of standards designed to meet the communications needs of various fixed-asset roadside devices and traffic management centers.

### 7-5.3. Inter-Agency Communication

ITS communications requirements are often divided into two categories according to the general environment in which the communications take place. One category is Center-to-Field (C2F) communications, which occurs for remote management of traffic roadside units and other ITS devices. The other category is Center-to-Center (C2C) communications. Many C2C platforms today communicate over industry standard Simple Object Access Protocol (SOAP) messages or XML file based approach. The implementation of C2F or C2C communication is the foundation of Inter-Agency communication.

## 7-6. CENTER-TO-CENTER ARCHITECTURE

The C2C environment is operationally diverse. All the systems that exchange information do not serve the same functions, but all the systems do use the Traffic Management Data Dictionary (TMDD) Standard for C2C Communications for data exchanges among centers. Even systems with the same functions may not operate identically. This diversity requires both a flexible approach to the required content in each data exchange and a rigorous definition of the data being exchanged.

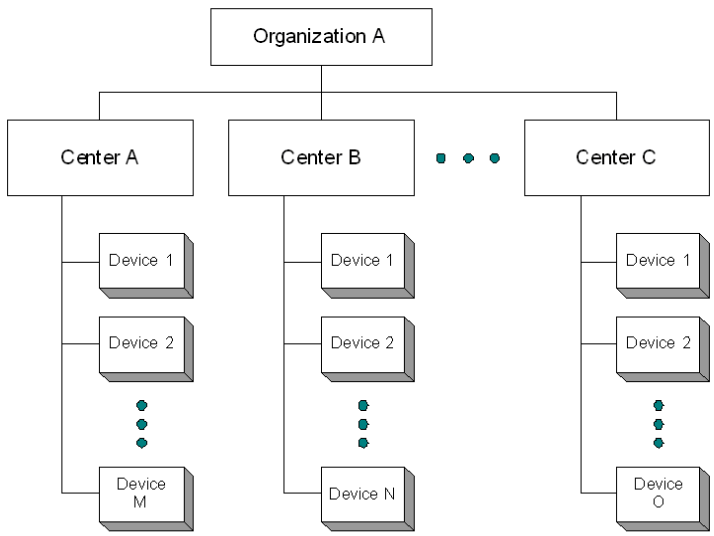
C2C communications can be used to:

- Provide event information and incidents to other centers
- Provide traffic and travel data to other centers
- Help coordinate operations within the defined C2C network
- Provide remote control of traffic control devices (AMS, CMS, etc.)
- Provide video image sharing to other centers

The C2C environment is sparsely deployed. There have been few large integrated regional deployments, so operational experience is available only from a few sites. Additionally, the time to fully deploy a regional or statewide system may be lengthy. The ITS standards development process uses a systems engineering process that requires a Concept of Operations (ConOps) document to define user needs. Further, the established system engineering process states that requirements must only be developed for those functions or operations for which a need has been established.

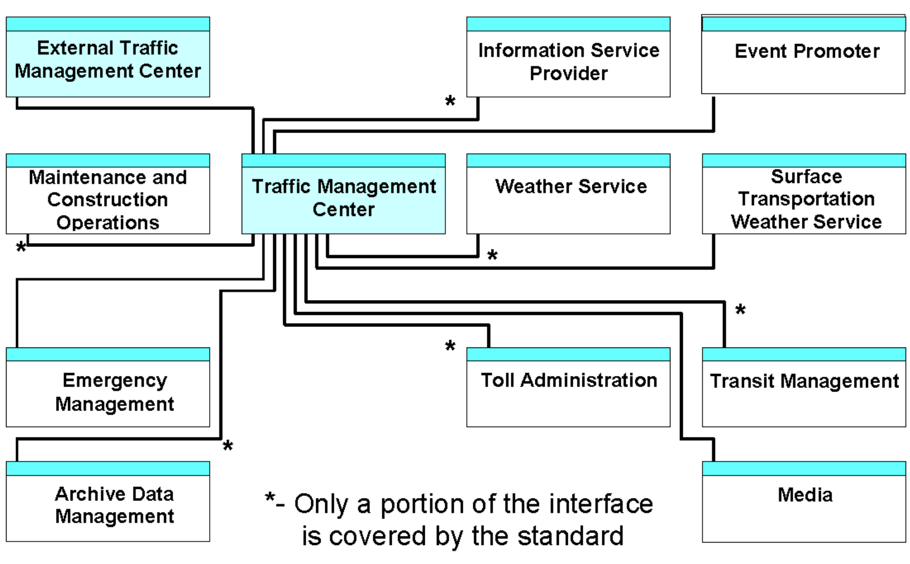
Utilizing NTCIP compliant protocols, from a high-level viewpoint the standard services and system interfaces that may be provided by traffic management centers to other external center subsystems (e.g. DACs) or workstations must be defined. The external center(s) may be other traffic management centers, subsystems, or system workstations identified in the national ITS architecture. The external center subsystems, or terminators, may be located physically in the same building or at a remote location. A typical arrangement of organizations, centers, and devices is shown in **Figure 7.3**.

**Figure 7.3 Typical Arrangement of TMC Organizations, Centers and Devices**




Once the organizational, operations center and devices have been defined, the flow set of data and communications between traffic management centers and sub-systems must also be established. A typical interconnect diagram defines a set of information flows for each interface shown in the diagram. As shown on by the shaded boxes, this is the interface from a traffic management center (TMC) to another external traffic management center (TMC). Each type of center is shown only once on the figure, but multiples of each center type will exist in many cases and each of their interfaces would be addressed by the C2C standard. A typical interconnect diagram is displayed below in **Figure 7.4.**

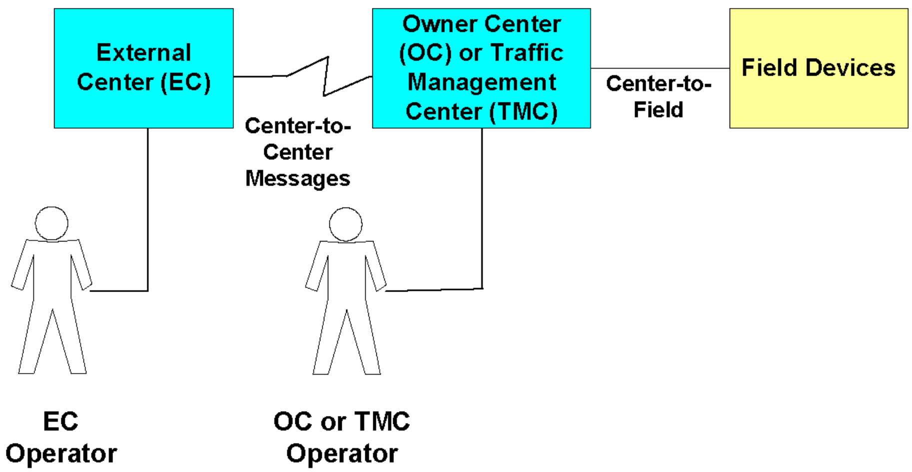
**Figure 7.4 Traffic Management Center Interconnect Diagram**



### 7-6.1. Owner Center / External Center

Where the information transfer relates to field devices as shown in **Figure 7.5**, the Owner Center (OC) will usually be a TMC. For other types of information transfers (e.g. event information) the owner center is the center that originates (and therefore "owns") the information. An External Center (EC) is an organization or a center that uses C2C services provided by another center. The TMDD standard defines the interface communications from an owner center (OC) to an external center (EC). For instance, for an EC to receive C2C messages from an OC, it must always have an "active" connection and be listening for messages from the OC, or the EC can schedule when to receive updated information at regular intervals or when the information from the OC is updated.

**Figure 7.5 External TMC Communication Environment**




### 7-6.2. User Classes

Classes of users are important to C2C operation to the extent that they represent the need to have varying levels of access to information and/or services. The user classes typically found in the Advanced Traffic Management System (ATMS) environment are ***Data Users*** and ***Operations Users***.

#### 7-6.2.1. Data Users

***Data users*** receive data from the TMC. They may use the data for specific purposes typically determined by an agreement with the data provider. There are many types of centers that might use data created by a TMC. These include:

- External Traffic Management
- Emergency Management
- Transit Management
- Maintenance and Construction Operations
- Information Service Providers
- Media
- Weather Service

- Surface Transportation Weather Service

In addition, the TMC itself may be a user of data obtained from the following centers:

- Media
- Event Promoters
- External Center

#### 7-6.2.2. Operations Users

***Operations users*** may use the information from a device or service and may also contribute to it (changing timing patterns of a signal controller or posting a message to a dynamic message sign). This class of user may also share device control as provided by other centers and may use sensitive information by agreement with the information provider. This type of user is primarily an external TMC, but in some cases centers such as Emergency Management may share operations of devices, including operational control.

### 7-6.3. Need for Connection Management

The following sections describe two distinct needs for connection management – verifying that a connection is alive and establishing the message patterns for exchanging C2C information.

#### 7-6.3.1. Verify Connection Active

Centers need to verify that a connection with another center is alive or active. If the connection between centers is alive then the information between centers is flowing.

#### 7-6.3.2. Need to Support Requests

Centers need to respond to requests for information or changes to information. This message pattern is the ability of an owner center to respond with a single message response to a single message request sent from an external center.

#### 7-6.3.3. Need to Support Subscriptions

Centers need to publish information to other centers that have subscribed to receive the information. External centers do not have the ability to determine when information at an owner center has been collected or updated. But by subscribing to information (or information updates), the external center can receive updated information at regular intervals or when the information is updated.

### 7-6.4. Sharing Traffic Management Data

The following represents a typical exchange of traffic management data between two (2) or more traffic operations centers.

### 7-6.4.1. Need to Provide Roadway Network Data

A traffic network represents a collection of roadway nodes, links, and routes. A node is the smallest data element that is unique within a network. Nodes provide a geographic location that can represent the beginning and end points of a link, location of a device, intersection, or location of an incident. A route is a collection of links. When a center elects to participate in a C2C environment, it may make available to other centers its traffic network information, which it uses to reference location of its center entities.

### 7-6.4.2. Need to Share CCTV Device Inventory and Streaming Video

Centers need to exchange HD IP CCTV inventory information and streaming video so that CCTV devices that are operated by a center can become known to other centers. Centers need to exchange CCTV device attributes so that the capabilities of the CCTV devices operated by the owner center can become known to external centers including viewing video streams. Inventory information includes static CCTV device attributes such as:

- Location
- Capabilities (pan, tilt, zoom, focus, BW/Color)
- Limits (tilt)

### 7-6.4.3. Need to Share DMS Status and Control

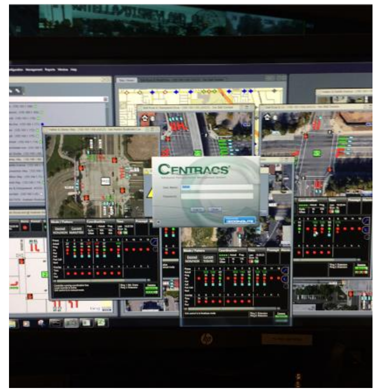
Dynamic message signs (DMS) are used by centers to help manage the surface transportation system. They can be used to:

- Provide travelers information that help the travelers select route
- Inform travelers about traffic congestion
- Inform travelers about travel times
- Inform travelers about roadway or traffic conditions
- Inform travelers about incidents
- Inform travelers about planned activities that may affect traffic conditions
- Provide information about transportation alternatives
- Provide parking management information
- Provide other public service announcements


Centers need to exchange status information for each DMS. Status information includes:

- Communications status (connected, disconnected, failed)
- Operational status (available, not-available)
- Current operational state information (contents of the display on the sign, etc.)

### 7-6.5. Center-to-Field Layout and Configuration

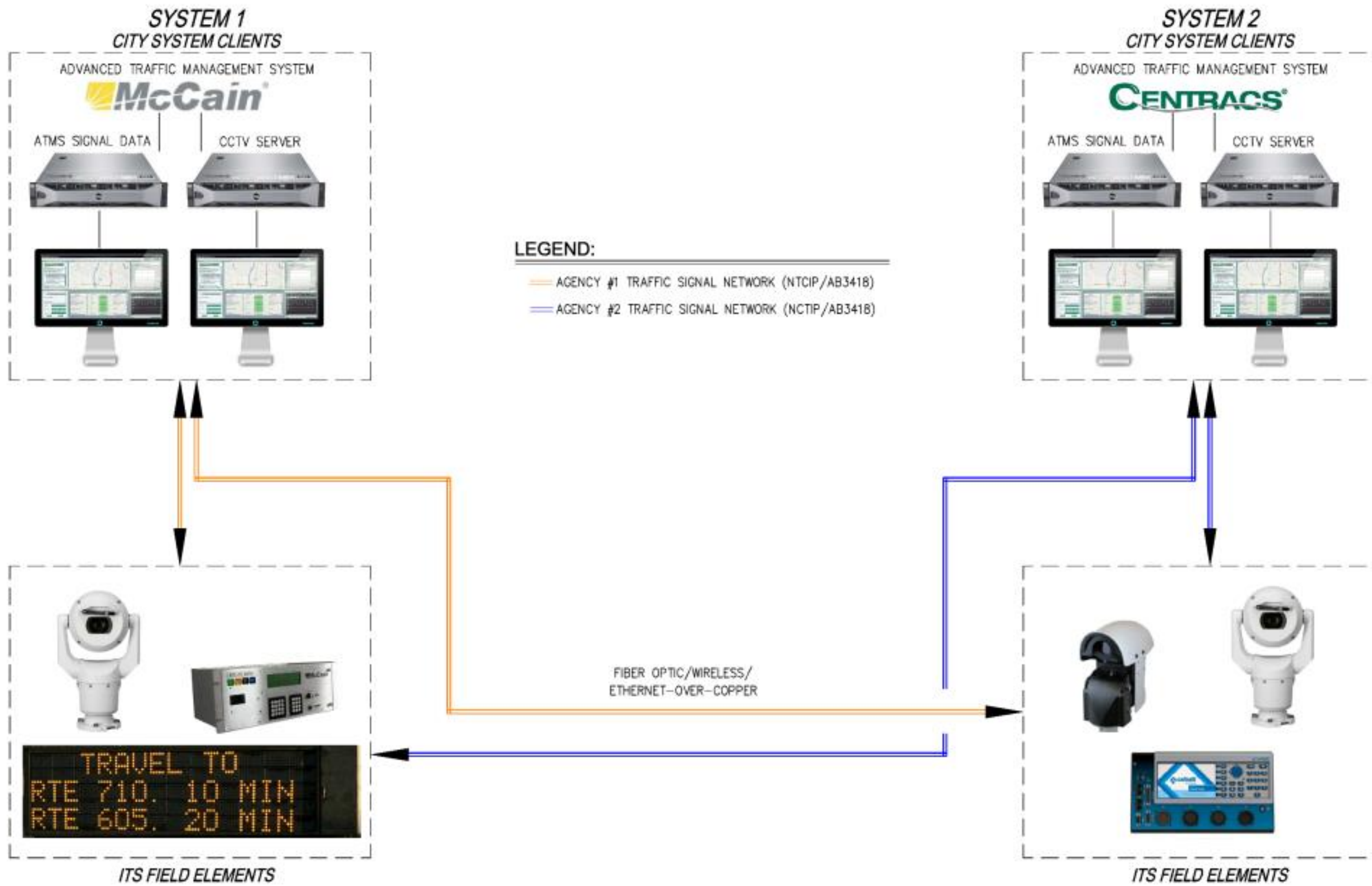



Multiple field devices communicate to centralized ATMSs located at localized TMCs. C2F communications occur on a regular basis for each agency's ATMS system as the central software will communicate with traffic signal controllers and other ITS field devices within each City. Typically, these devices use a poll rate of once-per-second, or 1 poll: second. The central system can then download and view information from the field devices such as traffic signal timing data, status, coordination timings, occupancy, volume, speed, video images, and arterial management data. The central system can then upload information or commands to the field devices such as updated traffic signal timing, camera Pan-Tilt-Zoom (PTZ) commands, or new messages for CMS signs. C2F communications can be applied to inter-agency coordination if a measure of understanding is agreed upon that specifies the privileges allowed by each city across the shared system. This type of approach is typically applied for intersections that are near or border city limits. Therefore, each agency is able to view/share traffic information for traffic signals that influence their signal and roadway operations.

**Figure 7.6** illustrates a Center-to-Field (C2F) communication schematic for sharing of information between two agencies with different central systems.

**Inter-Agency Communication Needs**

**Figure 7.6 Center-to-Field (C2F) Communications Exhibit**

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CENTER-TO-FIELD COMMUNICATIONS

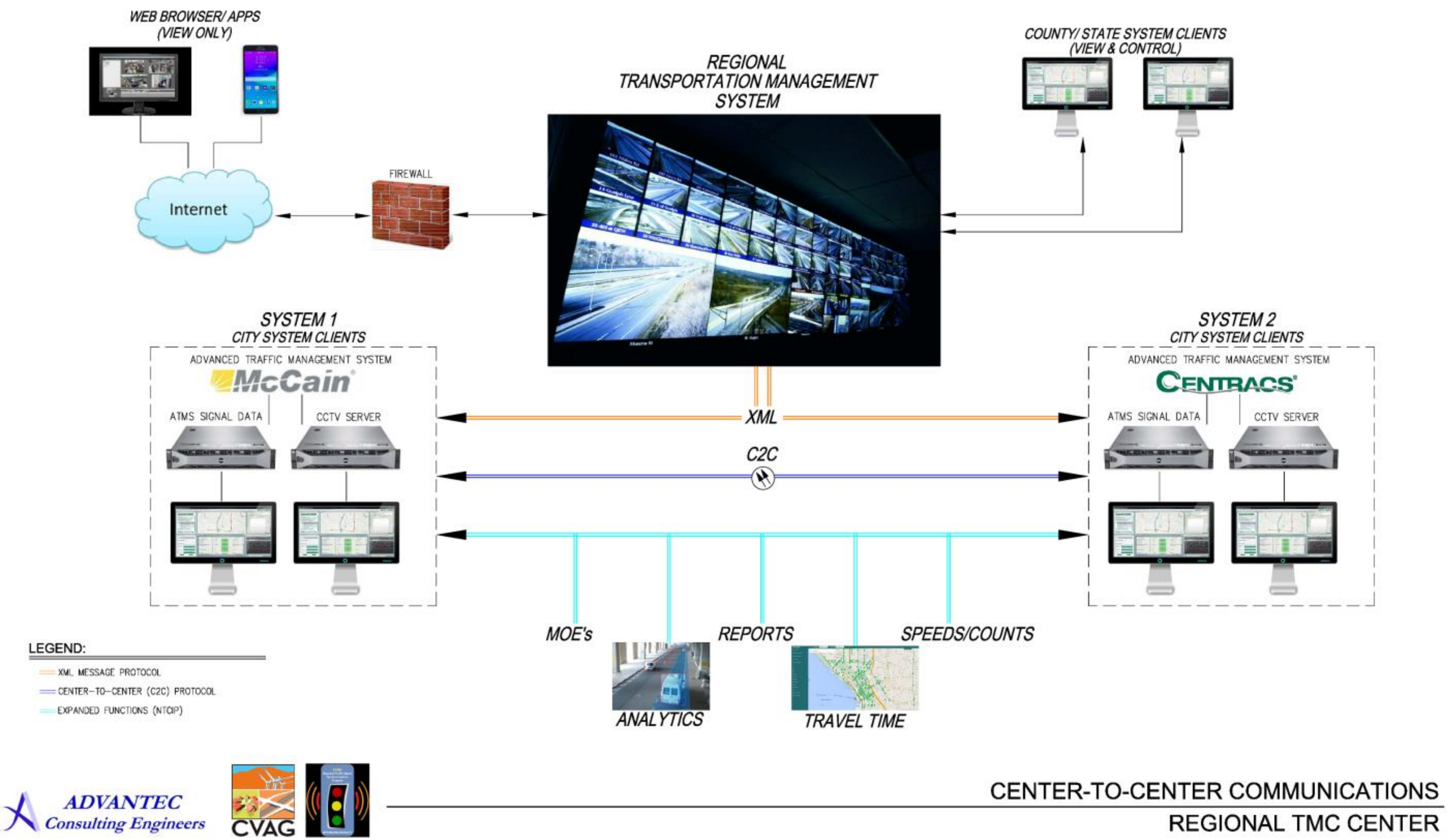
### 7-6.6. Center-to-Center Layout and Configuration

Two or more central systems can share information for traffic management and incident management. C2C communications can function between centers within the same agency or in outside agencies. The centers may not necessarily be in different physical places, but are logically separate. Similar to C2F communications, a measure of understanding is agreed upon that specifies the privileges allowed by each city/agency in the system. This can be described in a Memorandum of Understanding or Partnering Agreement. Typically, agencies will allow other agencies access to data or video from the system (view only), but will not allow separate control of the system.

An example of C2C communications is two traffic management centers that exchange real-time information about the inventory and status of traffic control devices. This allows each agency to know what timing plan/status the other agency is running to allow traffic signal coordination across agency boundaries. Another example of C2C communications is from a freeway management system to an emergency management system – it will post a warning message on a dynamic message sign to notify motorists of an incident ahead and provide alternate routes. During the design phase of the project, it is recommended to establish what information will be shared between each specific agency so that a defined a set of TMDD data objects will be considered for integration and deployment of the system(s).

**Figure 7.7** illustrates a Center-to-Center (C2C) communication schematic for sharing of information between two or more agencies, and at a regional level.

**Inter-Agency Communication Needs**
**Figure 7.7 Center-to-Center (C2C) Communications Exhibit**



### 7-6.6.1. Inter-Agency Connection

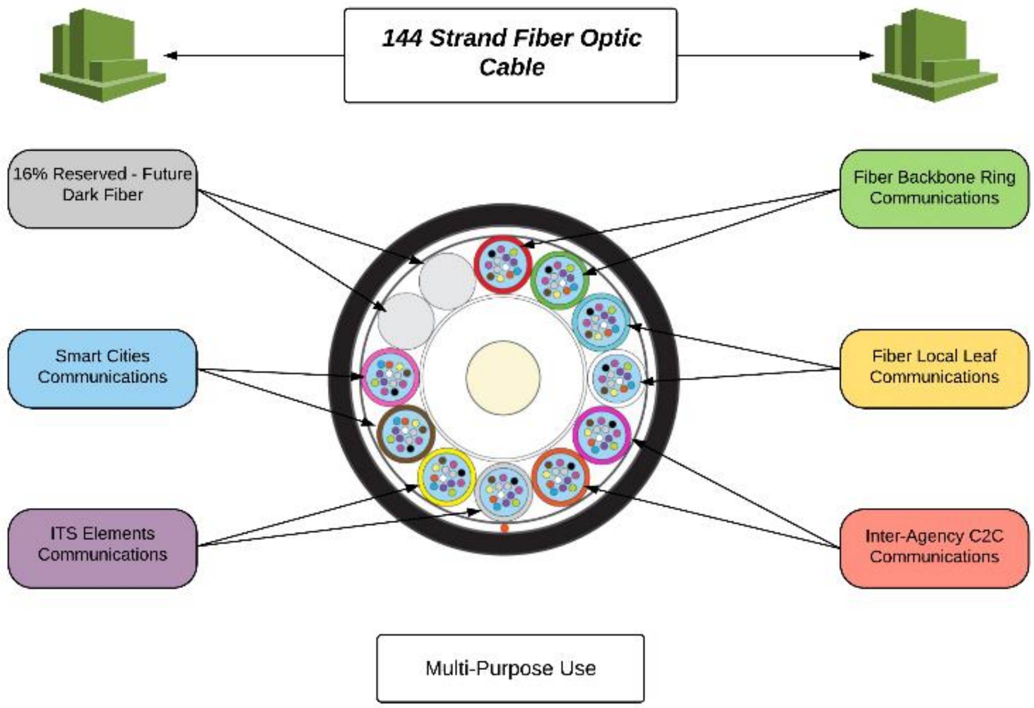
The ideal goal within the regional Coachella Valley TSI Master Plan is to provide a hardline connection from all established traffic management centers to sub-regional data aggregate centers and ultimately to a regional traffic management center. By providing a physical connection from all operation centers within the valley, we can provide a shared backbone of information across jurisdictional boundaries. For some centers, this vision may include sharing basic roadway data along a shared arterial, such as general timing data and coordination data so that an adjacent agency can then implement and coordinate shared arterial timing data accordingly. For other centers, a greater amount of data may be shared; such as real-time roadway traffic data, occupancy data, shared HD IP CCTV video images and control, CMS/DMS signage data, arterial management data, and weather based incident management dissemination.

In the Coachella Valley, Highway 111 traverses through the majority of local cities/agencies, and appears to be the best approach to provide a fiber optic communications trunkline to connect the local cities/agencies. In addition, several City Halls are located near the Highway 111 corridor, which provides an ideal solution to establish a high-bandwidth fiber optic network for these agencies. For agencies that cannot connect to a hardline fiber optic backbone, high-bandwidth wireless Ethernet back-haul links and/or worldwide web IPSEC VPN links are viable alternatives.

To accomplish this goal, all existing copper signal interconnect (SIC) cable is recommended to be replaced with new fiber optic cable while utilizing existing conduit, as necessary. If the communications along the entire Highway 111 corridor was replaced with fiber, over 20 miles of new fiber optic cable would provide for a stable, high-bandwidth interconnection between agencies. It is recommended to use high-density 144 strand fiber optic cable to be provided along Highway 111; its intended is to provide for local and back-haul interconnection links, center-to-center communications, regional communications, and to be expandable and scalable for future initiatives such as Smart Cities, Connected Vehicles, and reserved fibers for future use.

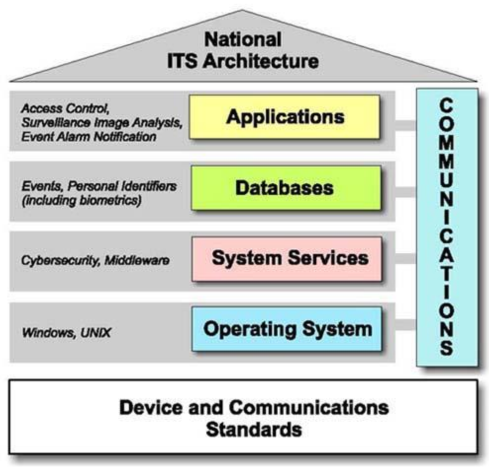
**Figure 7.8** illustrates the Fiber Optic cable allocation for a trunk line use along Highway 111.

**Figure 7.8 Highway 111 Fiber Trunk Line Cable Allocation**




### 7-6.6.2. Inter-Agency Control

Once a physical connection between centers has been established, a set of parameters needs to be implemented to establish the control and exchange of traffic information. This must be accomplished on many different levels. From a data transport application, rules must be in place to restrict what information goes where, otherwise TMC centers would be flooded with information from outside TMC centers with information that may not be specific to them.




To achieve this, the first step is to implement Ethernet IP access control list (ACL). An access control list is a list of permissions attached to an object, or IP packet frame. An ACL specifies which users or system processes are granted access to objects, as well as what operations are allowed on given objects. Each entry in a typical ACL specifies a subject and an operation. For instance, if a file object has an ACL that contains (TMC A: read, write; TMC B: read only), this would give TMC(A) permission to read and write the file and TMC(B) to only read it. On some types of proprietary computer hardware (in particular routers and switches), an access control list refers to rules that are applied to port numbers or IP addresses that are available on a host or other Layer 3 switch, each with a list of hosts and/or networks permitted to use the service.

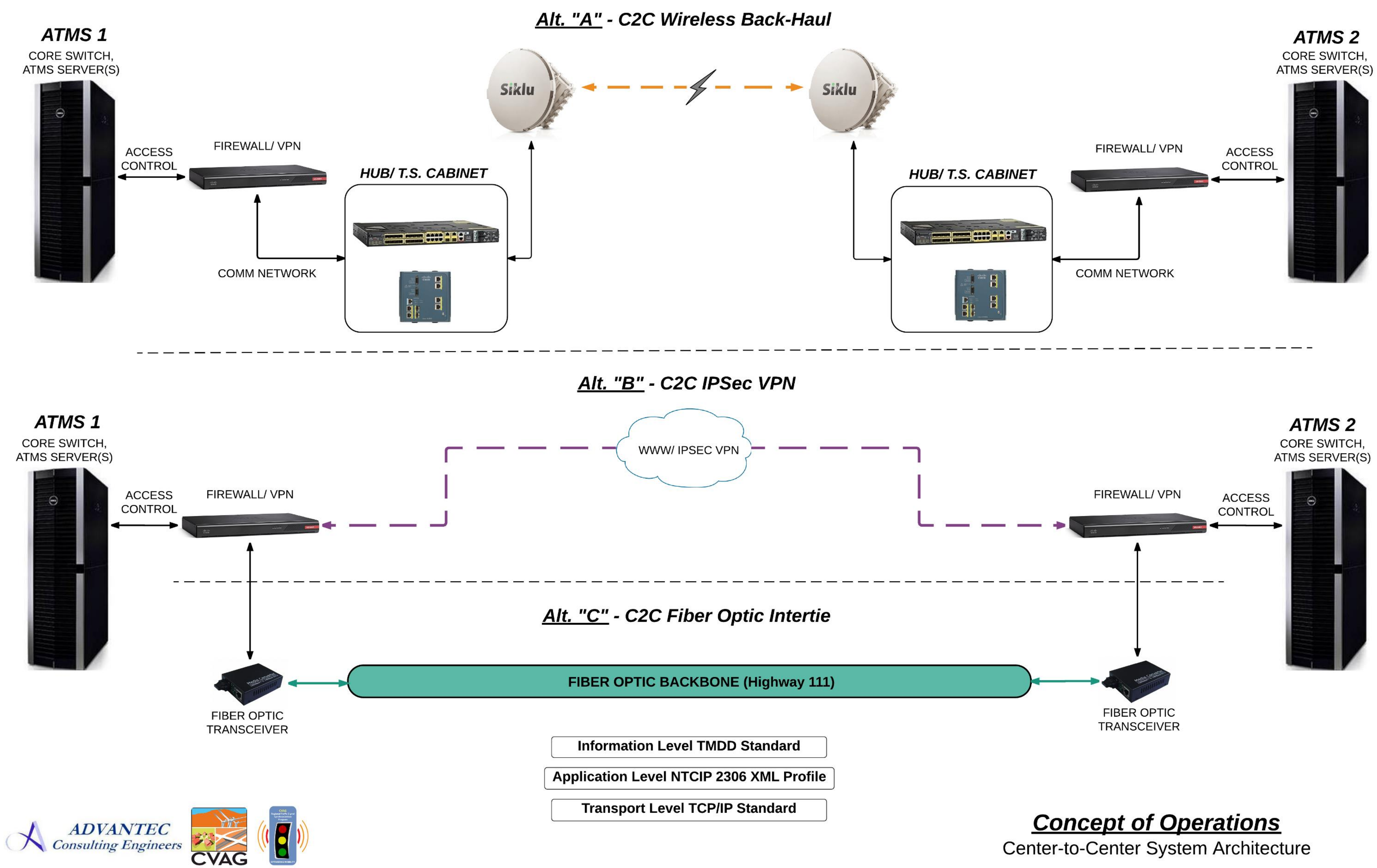
After these ACL security measures are in place, the next step is to further define local access and control between centers defined by manufacturers built-in security measures, such as creating separate "User/Admin" accounts as mentioned previously in this document. Along with network and local access and control in place, security and functions will vary from user-to-user based on role, responsibility and use case. For instance, a TMC Operator may have total administration rights which they can create, modify and implement new signal timing. Whereas other roles would be created to have local access rights only, which they can view the signal timing operation however they cannot create, implement or modify signal timing operations.

As previously shown in *Chapter 06, Concept of Operations*, **Figure 7.9** illustrates the system architecture/physical Center-to-Center (C2C) system interconnects for Inter-Agency communications.

**Figure 7.10** provides another level of detail that illustrates the logical Center-to-Center (C2C) system interconnects for Inter-Agency communications, including a Regional Center-to-Center (C2C) communication network topology for sharing of information within the entire Coachella Valley.

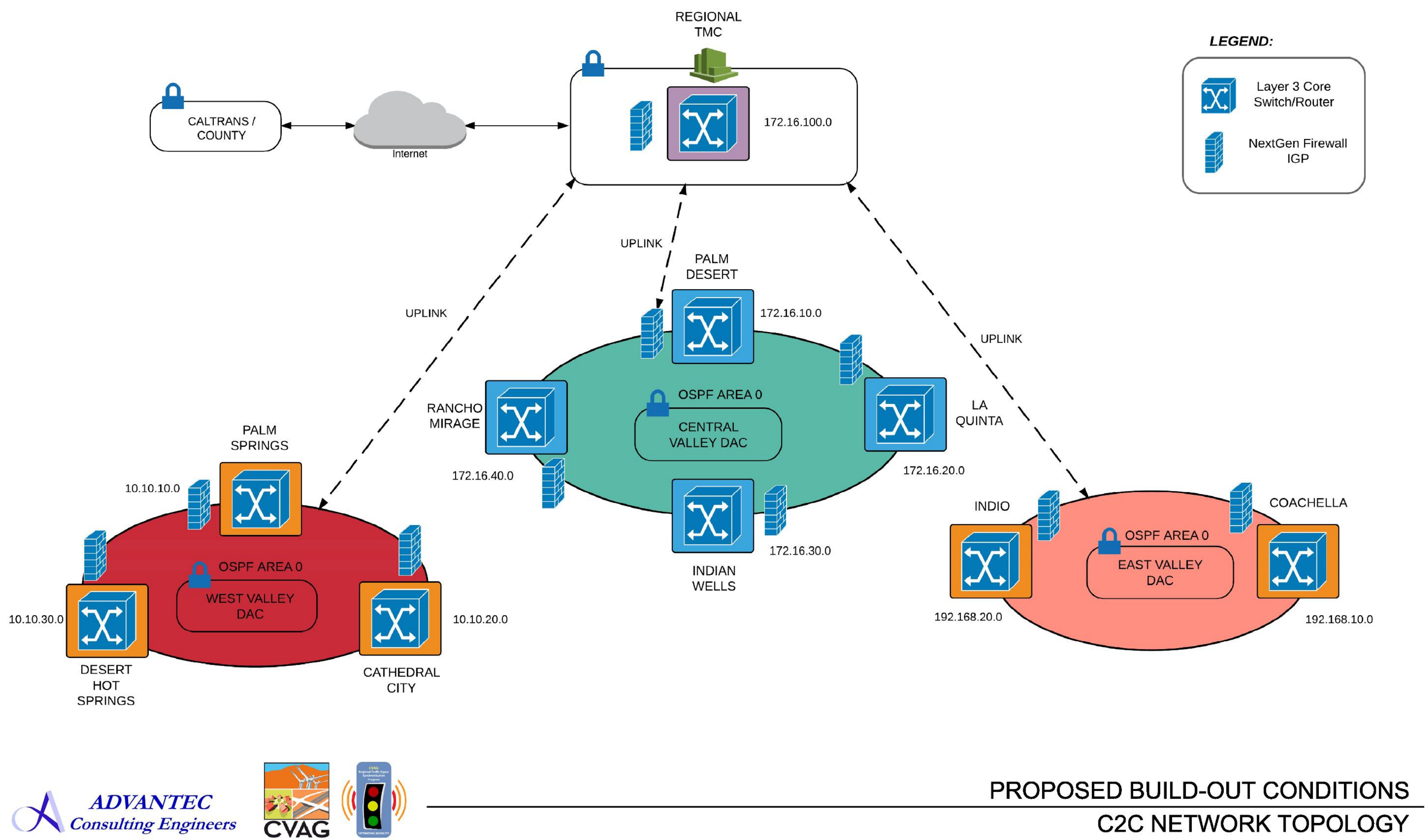
Inter-Agency Communication Needs

Figure 7.9 Proposed Inter-Agency Communications Exhibit



Inter-Agency Communication Needs

Figure 7.10 Proposed Inter-Agency Communications Exhibit



## 7-7. NATIONAL ITS ARCHITECTURE

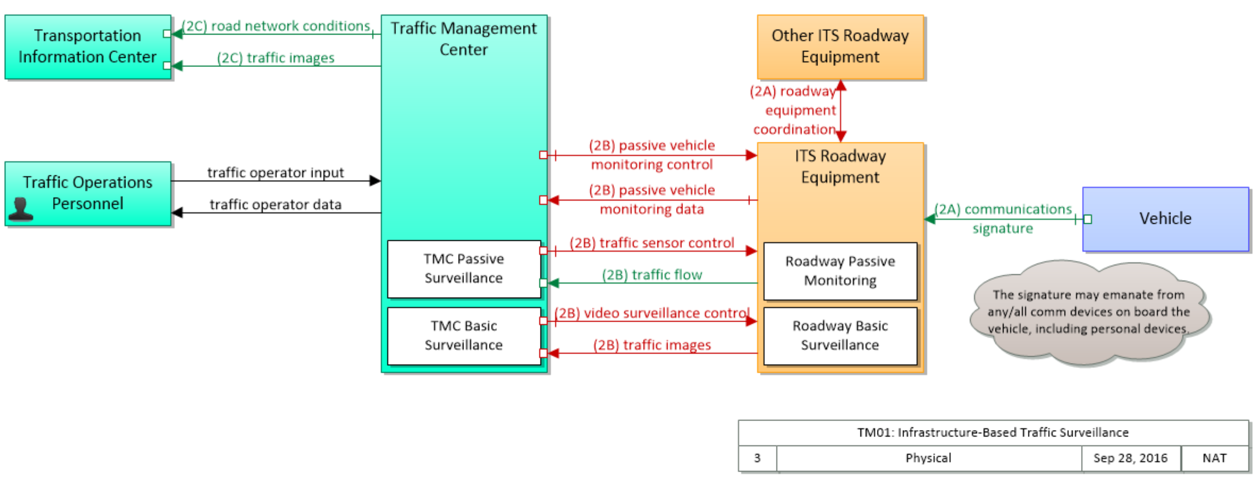
This section incorporates the U.S. National ITS Architecture and how it relates to providing inter-agency communications within the Coachella Valley. This section will show mappings and expand upon that scope discussion to consider the ITS Services, called "Service Packages" and the specific information flows, called "Architecture Flows" in the National ITS Architecture that will be addressed.

Service Packages represent slices of an architecture that provide a transportation service. In the National ITS architecture, these service packages are combinations of subsystems and architecture flows that are used to provide the service. For example, the Regional Traffic Management service package identifies the interfaces from one traffic management subsystem to another for the exchange of traffic information and traffic control messages. The following subsections identify the service packages supported by the TMDD. In all cases the standard supports not the entire service package but a subset of interfaces. The specific interfaces/architecture flows covered by the standard are identified in the service package diagrams by the ovals.

### 7-7.1. Network Surveillance

The Network Surveillance service package, shown in **Figure 7.11**, primarily covers the Traffic Management subsystem to Roadway subsystem interface for the collection of traffic flow and traffic images data.

**Figure 7.11 Network Surveillance**

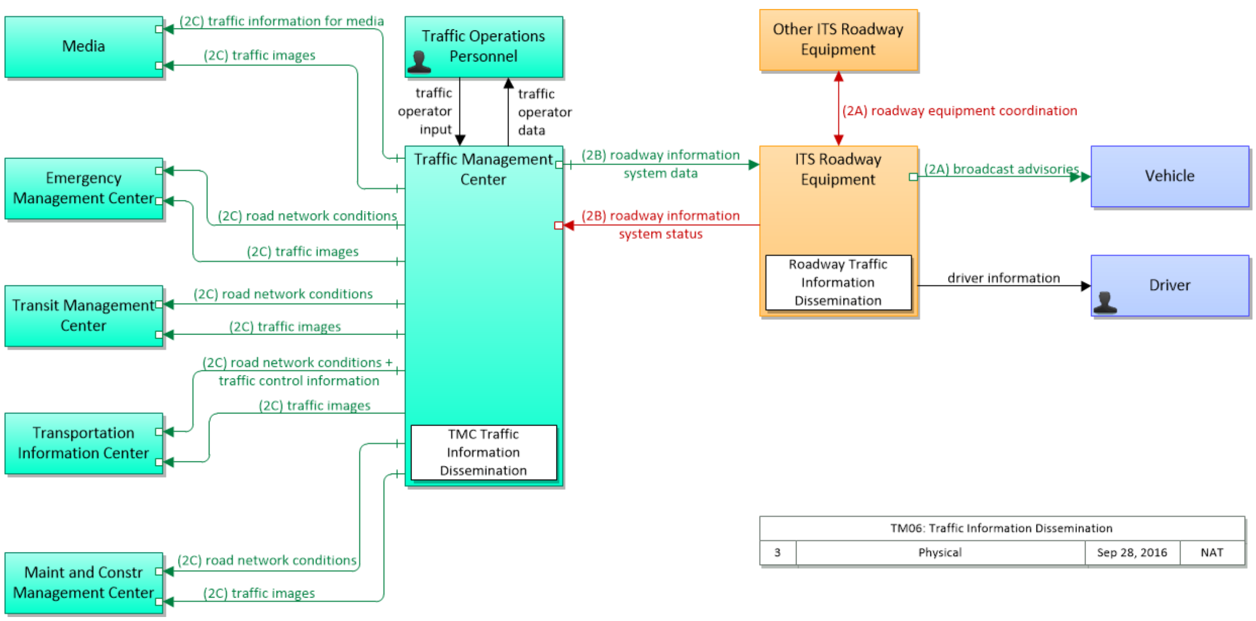



The service package also includes the transmission of road network conditions from the Traffic Management subsystem to the Information Service Provider subsystem.

## 7-7.2. Traffic Information Dissemination

The Traffic Information Dissemination service package, shown in **Figure 7.12**, covers the roadway interface that provides driver information using roadway equipment such as CMS signs or highway advisory radio (HAR). The service package also provides the interfaces that distribute traffic information from a traffic management center to the media, for instance via a direct tie-in between a traffic management center and radio or television station computer systems, Transit Management, Emergency Management and Information Service Providers.

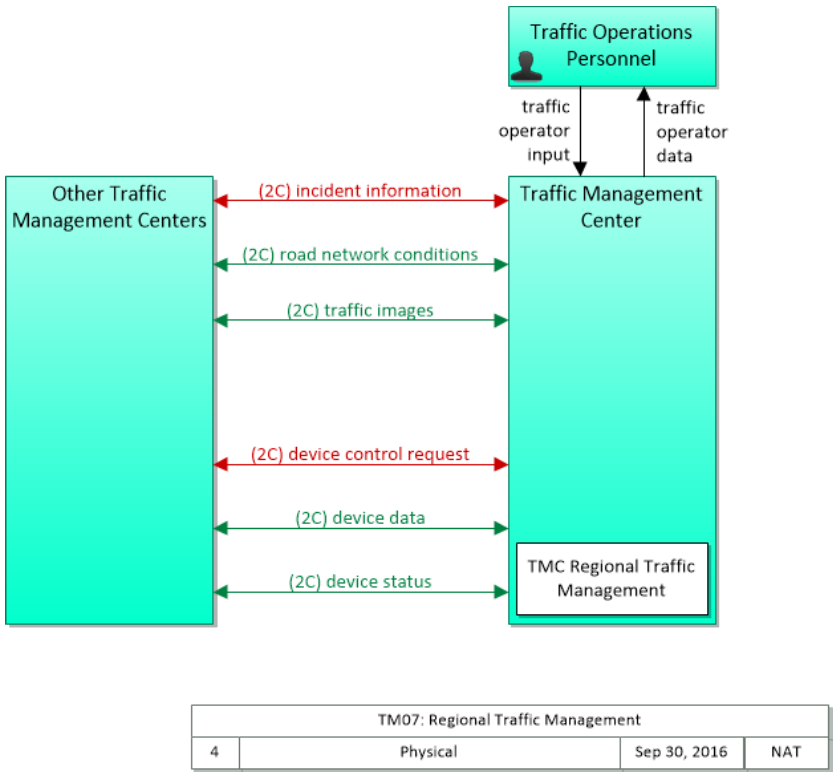
### Figure 7.12 Traffic Information Dissemination



### 7-7.3. Regional Traffic Management

The Regional Traffic Management service package, shown in **Figure 7.13**, provides for the sharing of traffic information and control among traffic management centers to support some regional traffic operations. The key interface items are shown below.

**Figure 7.13 Regional Traffic Management**



## 7-8. Sub-Regional Data Aggregation Center

Sub-Regional Data Aggregation Centers (DAC) are locations where one agency takes the lead role in interconnecting adjacent ATMS systems and sub-systems of the same type (i.e. Econolite-Econolite, McCain-McCain). By consolidating core central systems at the sub-regional level (East Valley, Central Valley, West Valley) we are then able to utilize common integration efforts across one manufacturer for a sub-regional DAC to provide an uplink connection to the Regional Traffic Management Center (RTMC). This approach will help streamline the integration process for ATC controllers and other ITS elements of the same type for sharing information across jurisdictional boundaries. It should also be noted that the use and control of each ATMS will be maintained by the local agency.

There are three (3) proposed sub-regional data aggregation centers (DAC) where the intent is to consolidate traffic operations of the same type/layout; and to provide three distinct sub-system DAC's in the Coachella Valley.

- **West Valley DAC** : **Palm Springs** (McCain)
  - Local TMC's include: cities of Cathedral City, Desert Hot Springs
- **Central Valley DAC** : **Palm Desert** (Econolite)
  - Local TMC's include: cities of Rancho Mirage, Indian Wells, and La Quinta
- **East Valley DAC** : **Indio** (McCain)
  - Local TMC's include: city of Coachella

It is anticipated a Sub-Regional DAC will house additional equipment such as upgraded Video Wall or monitors with video wall controller, specialized A/V hardware equipment and additional database servers serving local TMC functions within the area. Furthermore, a sub-regional DAC will require additional licensing for integration and oversight of adjacent local TMC owned traffic signals. In addition, extended system integration efforts will be required to connect multiple traffic networks at the sub-regional level, and then ultimately to the regional TMC.

To interconnect Local TMC's and ATMS of the same manufacturer, specific network routing protocols will be implemented per the requirements of the Regional TSI Master Plan and will be provided in more detail during the design phase. Specifically, at the sub-regional DAC level, an Interior Gateway Protocol (IGP) will need to be implemented to advertise routes and interconnect different networks and sub-networks. Examples of IGP protocols are; RIP (routing information protocol), OSPF (open shortest path first), and EIGRP (enhanced interior gateway routing protocol). As indicated in **Figure 7.10**, OSPF is shown for interconnecting networks at the Sub-Regional level. Resources from the systems integrator and vendors alike will be required to provide a cohesive C2C operating environment. Once an IGP protocol is implemented, local Agencies may then begin to share traffic data and video streams between networks within the same area.

**Figure 7.14** provides a general Interior Gateway Protocol OSPF topology layout.

**Figure 7.15** provides an illustration of a Sub-Regional DAC layout and interconnection.

**Figure 7.14 General OSPF Topology**

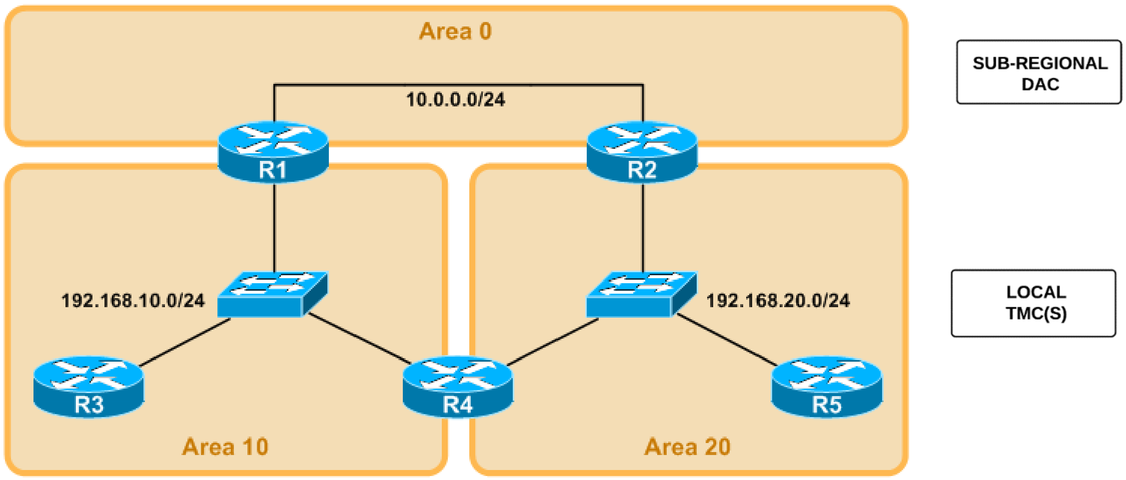
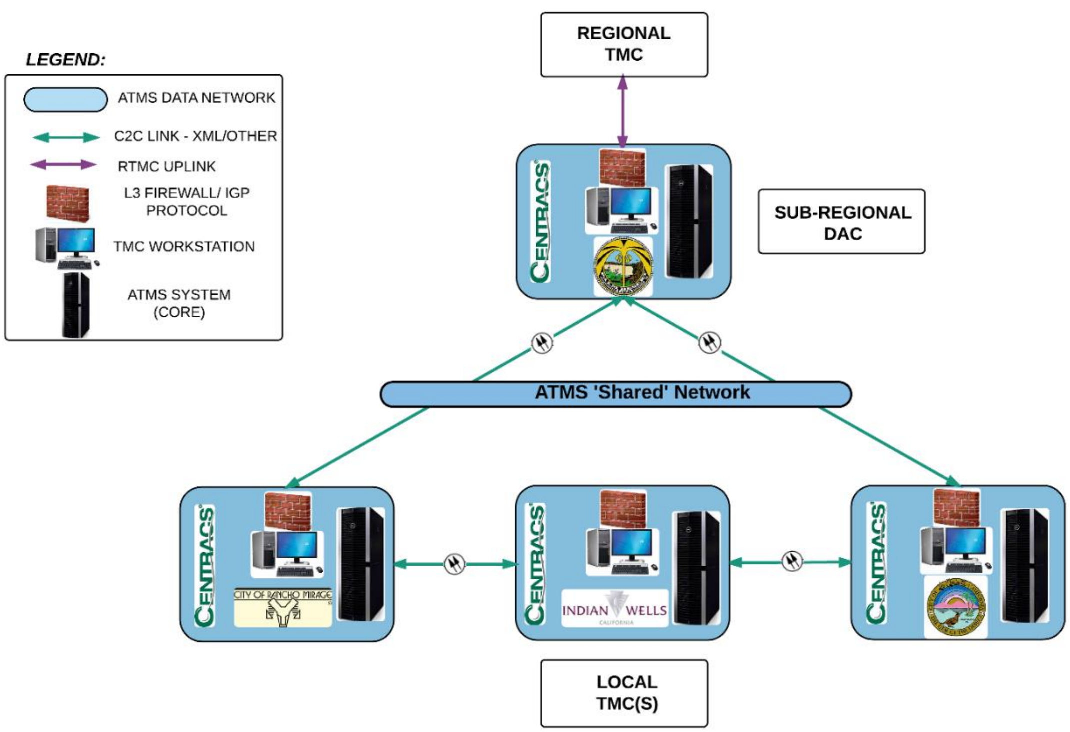



**Figure 7.15 Sub-Regional TMC Exhibit**



## 7-9. Regional Traffic Management Center (RTMC)

As the Coachella Valley expands their plans for traffic signal coordination, and video and data sharing, inter-agency communication will become a valuable asset. Several corridors carry large amounts of traffic across city boundaries. In order to maintain vehicle platoons over these segments, traffic signal controllers will need to function on common cycle lengths and coordinated signal timing plans. Time-of-Day coordination plans will be created for corridors, and will be implemented in each respective city. With C2C communications separate agencies can view changes in coordination status and adjust its time of day plan accordingly, or respond to a specific incident.

The implementation of a regional and/or area wide Traffic Management Center (TMC) could provide as a host for the entire Coachella Valley region. Separate sub-regional TMC systems or termination stations would interface to the regional TMC through C2F or C2C communications. While this type of regional application may provide a more centralized and unified approach, it is important to consider the space required, operations and maintenance, and staffing needs required to implement such a management center. The regional system would be intially deployed for operations and maintenance of traffic operations only, however, additional applications such as emergency operations, police/fire dispatch, and local traffic dissemmination for future Integrated Corridor Mangement (ICM) functionality provides a unified approach to both the public and elected officials with a consistant message.

For a successful deployment of corridor synchronization and signal operations across adjacent agencies, a Regional Traffic Management Center (RTMC) and sub-regional DAC's should be monitored consistently. Many local cities/agencies traffic signal systems operate on different traffic controller firmware and/or TMS systems; therefore, center-to-center (C2C) communication or an area wide TMC would provide for shared traffic signal information on an arterial between regions and with other local cities/agencies.

The sub-regional DACs provide the tools for real-time optimization and coordination of traffic signals between agencies with the same operating systems, and have the ability to share traffic data on major arterials including performance measure reporting and potentially shared maintenance practices and resources. The DACs also provide two-way communication and uplinks to the RTMC that would provide advanced traffic management at a regional level.

The scope for a RTMC is more involved than a standard local or sub-regional DAC. In general, complex Advanced Traffic Management Systems (ATMS) that use complete open architecture is required to interface to several other different ATMS and other ITS elements. These open architecture systems are still referred to as "ATMS systems", however they differ from conventional ATMS systems in that they do not perform actual traffic signal operations. They essentially act as in interface, some with over 30 different "modules" that encapsulate each ITS sub-system and integrate them into one Graphical User

Interface (GUI) for the RTMC operator. The module-based approach enables cities as well as state DOT's to adopt new technologies such as Connected Vehicles quickly and utilize them in their existing environment for immediate benefits. Therefore, the open architecture containing different "modules" provides user flexibility and scalability as the agency grows.

The following is a list of integrated modular systems that may be deployed for the Regional Traffic Management Center (RTMC):

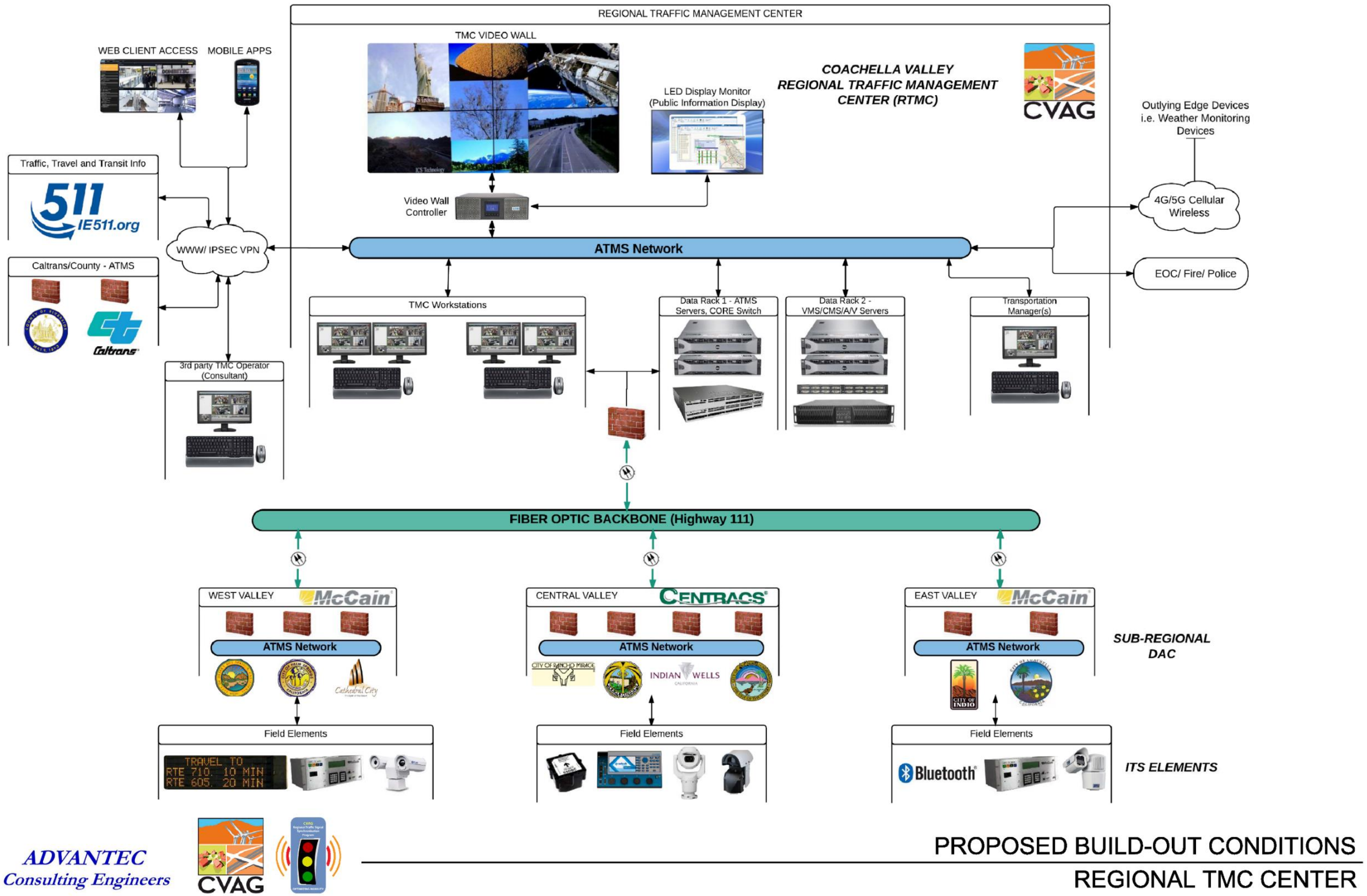
- Traffic Signal Management
- Changeable Message Signs
- Traffic Surveillance Cameras
- Incident and Event Management
- Weather and Environmental Sensors
- Highway Advisory Radio (HAR)
- Arterial Management Systems
- C2C Integration Module(s)
- Smart Parking / Guidance
- Connected Vehicles

It is envisioned that the local city/agency TMC's will still maintain control of their systems and through a cooperative agreement (e.g. Partenering Agreement), data and video may be shared with partner agencies and stakeholders for viewing purposes only. This may be accomplished by implementing strategies like C2C communications, sharing communications over fiber optic, copper or wireless, and remote access to traffic and/or video management systems. All local cities/agencies would maintain traffic signal timing and operations control. They would only be providing traffic data to the sub-regional DAC and/or the regional TMC. This would be an effective use of the the traffic information being collected during special events or during busy periods in the Coachella Valley. Overall, there is a potential cost/time savings through addressing regional operations just once rather than multiple times for individual cities and/or arterials. This will require coordination and cooperation with partner agencies that have major arterial roadways crossing through their jurisdictions.

**Figure 7.16** illustrates a Regional Traffic Management Center (TMC) and the "build-out" configuration for interconnection of ATMS systems within the entire Coachella Valley.

**Inter-Agency Communication Needs**

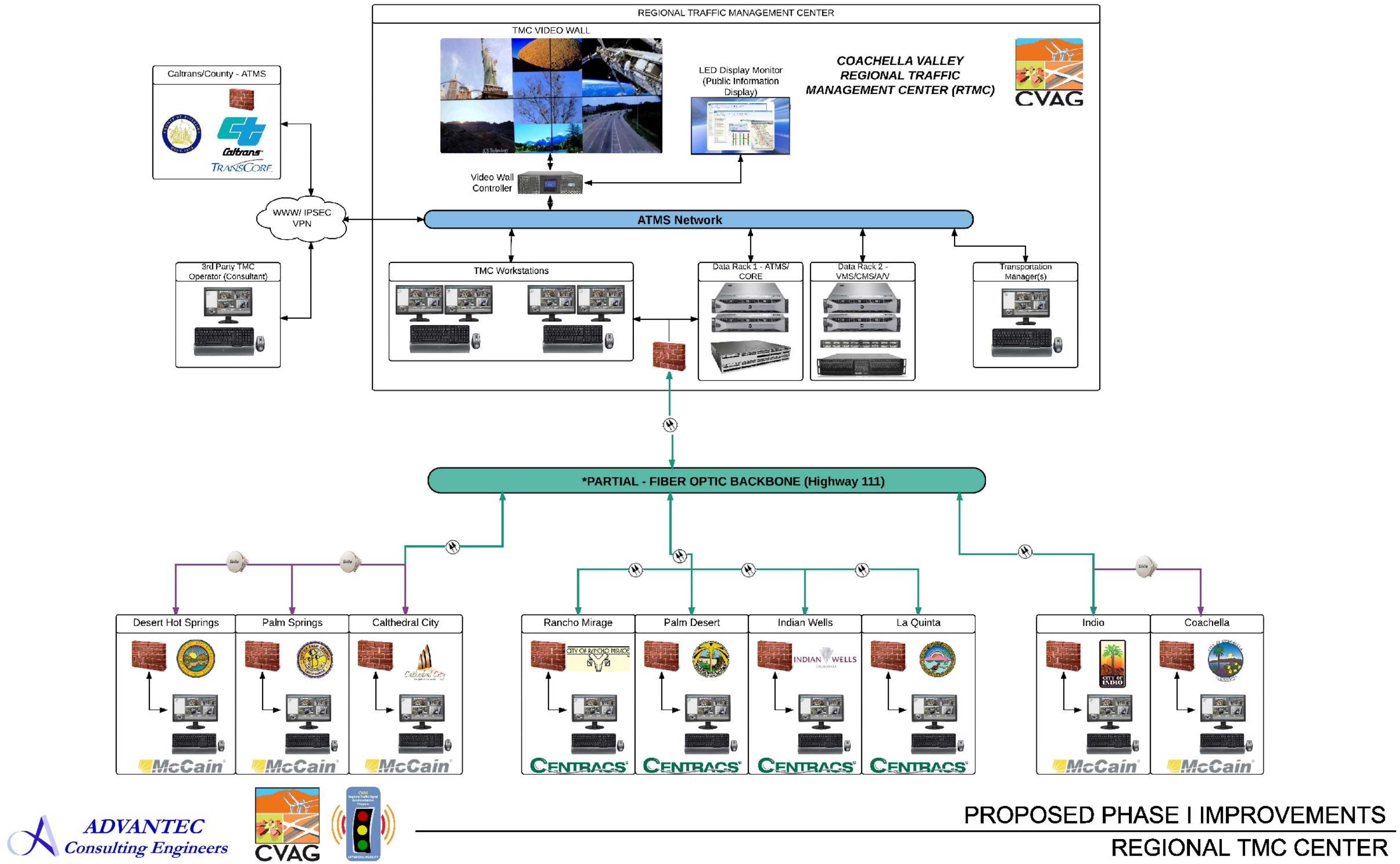
**Figure 7.16 Regional Traffic Management Center (TMC) - Ultimate Build-Out Conditions**



It is anticipated as part of the Phase I funded implementation of the region wide ITS improvements, the total number of improvements required to meet the "Build-out" conditions of the entire regional C2C interconnected layout above will not be accomplished. Therefore, **Figure 7.17** illustrates a partial "Phase I" funded condition of the proposed Regional Traffic Management Center (RTMC) configuration for interconnection of ATMS systems until further recommendations and improvements can be made.

## Inter-Agency Communication Needs

### Figure 7.17 Regional Traffic Management Center (TMC) - Phase I Funded Improvements



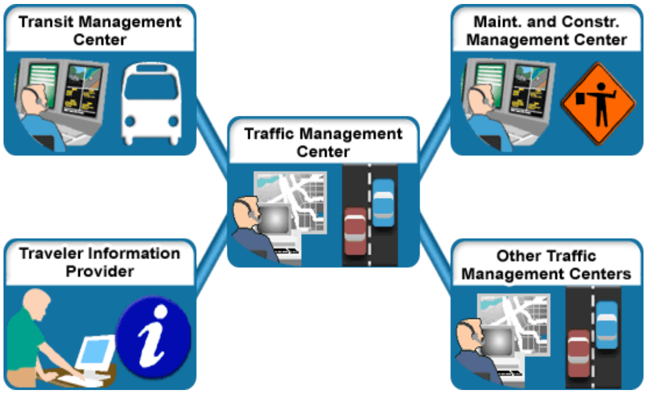
### 7-9.1. TMC Building and ITS Staffing Requirements

Currently, there is no regional traffic management center currently deployed in the Coachella Valley. Therefore, adequate space will need to be acquired in a centralized area to provide for such operations. The goal is to provide for a location that will house the necessary equipment and provide adequate staffing levels to operate and maintain a regional Traffic Management Center (TMC) and Advanced Traffic Management System (ATMS).

#### 7-9.1.1. TMC Building

The purpose of the proposed regional traffic management center is to acquire and cater to both existing and future ITS equipment based on the regional and sub-regional agency requirements. Ideally an architectural space will need to be designed to optimize space to house a Traffic Operations Room, IT Data Server Room, Storage Room, and Layout Room conforming to the following requirements:

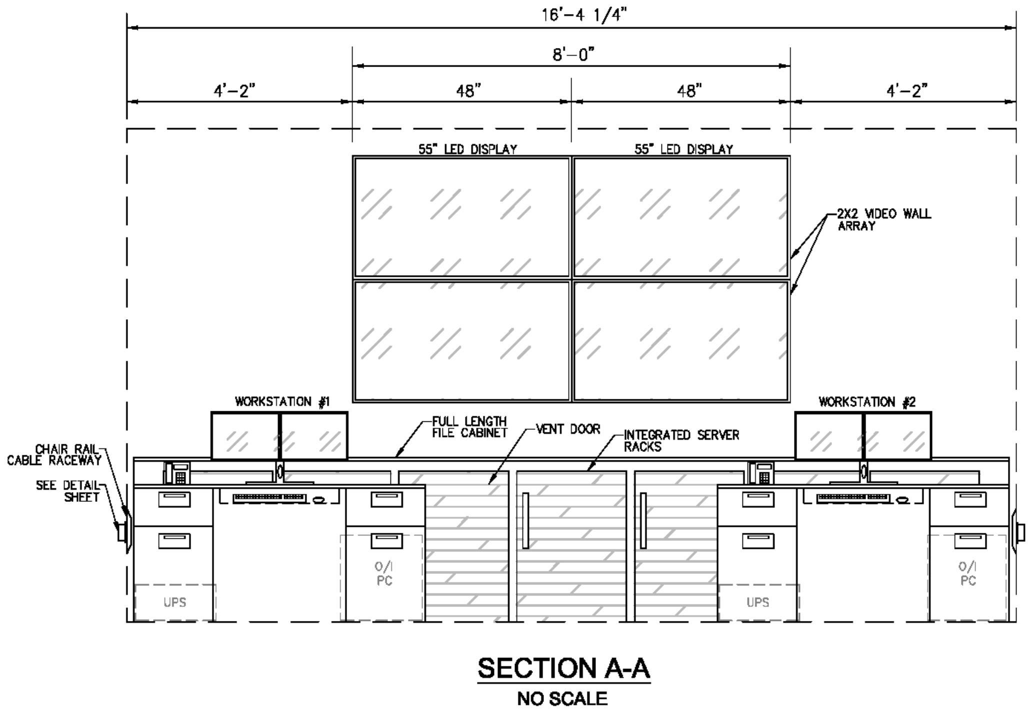
- Building location/ Zoning within local business and/or Industrial zoned area
- Ingress and Egress requirements
- Structural capacity
- Fire Safety
- Electrical Improvements:
  - Adequate power source
  - Power Panel upgrade
  - Lighting
  - Telecom/ IT Data Racks
  - Cabling/ Raceways/ Raised Floor
  - Smoke detectors
  - Air Conditioning
  - HVAC
  - UPS power / Generator
- Data Center to house all TMC core equipment
- A/V equipment/ integration
- LED Video Wall / Video Wall controller
- TMC Furnishings



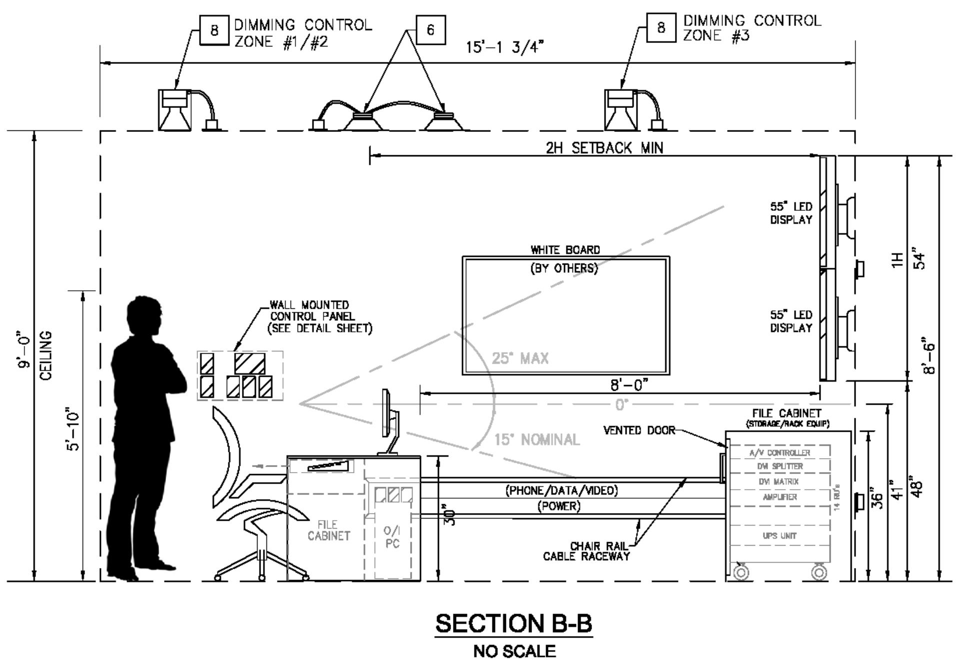

The required architectural buiding design for a dedicated RTMC is currently not included under this contract. Complete and detailed design plans and calculations will need to be submitted via third party coordination and agency approval.

**Figure 7.18** and **Figure 7.19** illustrate a sample conceptual design of a Regional Traffic Management Center (RTMC) layout.

### Figure 7.18 Conceptual Design for Proposed Regional TMC Center




### Figure 7.19 Conceptual Design for Proposed Regional TMC Center - Layout



If the optimum space and location is not currently available, an interim solution shall be considered. At a minimum, it will require determining the location of the Traffic Operations Room and IT Data Server Room.

### 7-9.1.2. ITS Staffing Requirements

Based on the new TMC, ATMS, and ITS elements, additional staffing or hiring a third party (consultant) should be considered to monitor and maintain the systems. This requires estimating the level staffing to serve current and future needs. To serve the current needs, hiring a third party (consultant) may be the best solution until there is a full understanding by the owner regarding the level of skill, and involvement of daily operations and maintenance before hiring full time personnel. At the build-out conditions, a typical staffing structure and requirements for large scale TMC operations can be depicted in **Figure 7.20**. However, under the current Phase I implementation of a regional TMC, local TMCs, ATMSs, communication, and ITS improvements – the total staffing levels as shown in **Figure 7.20** will not need to be met immediately.

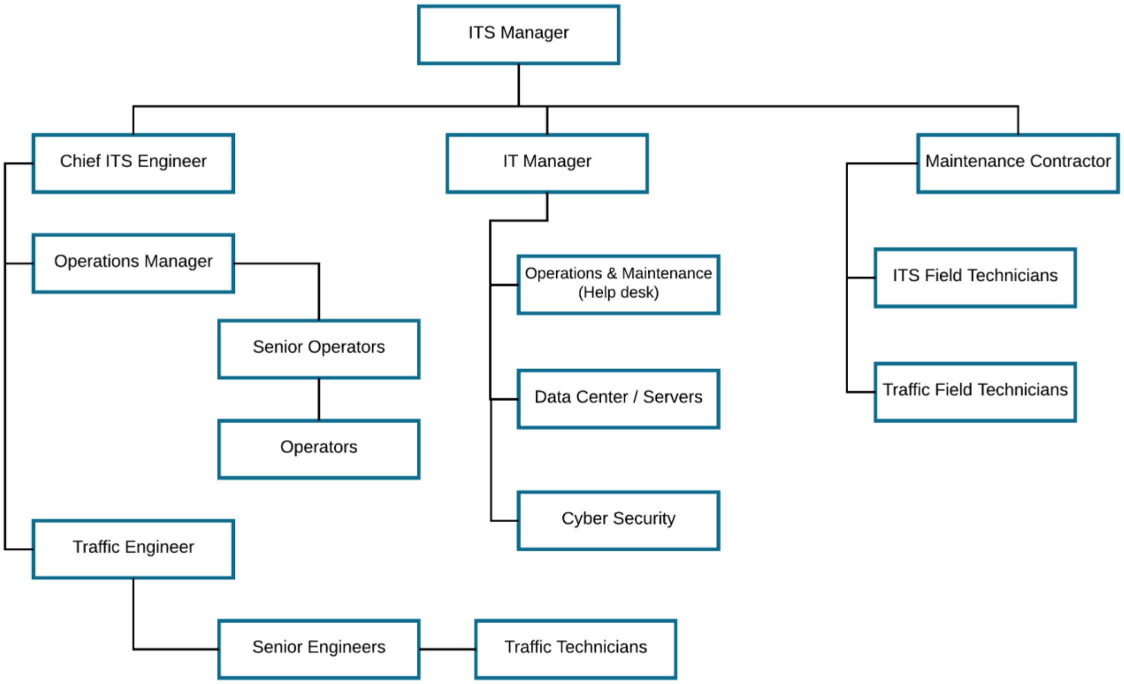
Therefore, based on these assumptions, it is recommended that a reduced staffing level be established and approved, consisting of:

- Two (2) ITS specialist staff work on ITS operations and maintenance located at the RTMC. They should be supplemented by:
    - System Administrator
    - Senior TMC Operator
    - IT Engineer
    - Two (2) field based Signal and ITS Technician(s)

Because of its size and complexity, a regional TMC should base its core operations off two 8 hour shifts to cover the morning AM peak and the afternoon and evening PM peak periods. Also, the regional TMC should be in operations during major events in the Coachella Valley (e.g. Coachella Festivals). In addition, open working space should be dedicated and reserved within the regional TMC for representatives of other agencies involved with the overall activity of traffic and transport operation within the valley. The regional TMC may also be considered as the regional Emergency Operations Center (EOC).

**Figure 7.20** illustrates a proposed staffing structure for large scale TMC operations such as a Regional Traffic Management Center (TMC).

**Figure 7.20 ITS Staffing Structure for Large Scale TMC**




### 7-9.1.3. Operations and Maintenance (O&M) Requirements

After approved design and deployment of local TMCs, sub-regional DACs and regional TMCs are built in the Valley, there is an added Operations and Maintenance (O&M) costs associated with running and staffing a dedicated TMC. Generally, staffing requirements can be broken down into three (3) distinct areas:

- In-House
- Outsourcing
- Facilities Management Staffing

Staffing can further be broken down into different sub-roles, such as: System Administrator (SA), Traffic Engineer (TE), TMC operator and Technology (IT) support.

In-house staffing would comprise of a team of dedicated staff to perform daily traffic operation tasks and regular maintenance on their traffic signal system. It is envisioned a new system will require additional training regarding operations and maintenance on the new ATMS, Video Management Systems (VMS), Arterial Management Systems, CMS and other ITS technologies. Ideally, this would be a preferred option since all operations and maintenance is performed within the same organization.

Outsourcing of TMC staffing needs results in additional costs to the organization on an annual basis, however could be the solution for agencies without the available resources for dedicated Traffic Engineers (TE), TMC operators and IT support. Private transportation firms often have the knowledge and expertise to manage independent traffic systems either remotely via VPN connection or on-site for dedicated number of hours per day.

In addition, to meet further operational requirements, it is advised that maintenance contracts be established at the end of each commissioned system for further upgrades and maintenance to each respective system (ATMS/VMS/Arterial Management, etc.). Therefore, each specific vendor would maintain their system periodically (quarterly/on-call) for a specified length of time, i.e. 3 years after initial deployment.

**Table 7.1** shows the staffing type/personnel, and the typical hours required to perform routine operations and maintenance for a Regional TMC including projected costs and staffing options (in-house or outsourced) to be considered.

**Table 7.1. ITS Staffing Resources and Potential Costs**

| Staff | Hours Hours/Week | Hourly Cost | Annual Cost | Staffing Option |
|---|---|---|---|---|
| **ITS Manager / System Administrator** | 10 | $90 | $46,800 | Existing/New Staff |
| **TMC Operator 1** | 40 | $60 | $124,800 | New Staff |
| **TMC Operator 2** | 40 | $60 | $124,800 | New Staff |
| **Senior Operator** | 20 | $80 | $83,200 | New Staff |
| **IT Engineer** | 40 | $70 | $145,600 | Existing/New Staff |
| **Signal Technician 1** | 40 | $60 | $124,800 | New Staff |
| **ITS Technician 2** | 20 | $70 | $72,800 | New Staff |
| **(Staff Cost) TOTAL:** | | | $722,800 | |

**It is** anticipated three (3) sub-regional DAC's will be deployed.

**Table 7.2** provides a preliminary cost estimate of the ITS hardware/software and A/V infrastructure required for a Regional TMC in the Coachella Valley.

**Table 7.3** provides a preliminary cost estimate of the ITS hardware/software and A/V infrastructure required for **a singular Sub-Regional DAC** in the Coachella Valley. It is anticipated three (3) sub-regional DAC's will be deployed.

## Table 7.2. Regional TMC Infrastructure Cost

| Item No. | ITEM DESCRIPTION | Quantity | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|---|
| | **FIELD ELEMENTS** | | | | |
| 1 | Fiber Optic Cable | 5260 | LF | $7 | $36,820 |
| 2 | Conduit (3") and pull boxes to Region TMC center | 5260 | LF | $43 | $226,180 |
| 3 | Radio Antenna High Mast - Regional TMC center | 1 | EA | $10,000 | $10,000 |
| 4 | Wireless Ethernet Bridge (Back-Haul Radio) for C2C Intertie | 3 | EA | $15,000 | $45,000 |
| 5 | Managed Hardened 24-port Gigabit Ethernet Switch with SFP options | 1 | EA | $8,000 | $8,000 |
| 6 | Communication HUB Cabinet, foundation, power complete | 1 | EA | $25,000 | $25,000 |
| 7 | Fiber Distribution Unit & Fiber Termination | 1 | EA | $5,000 | $5,000 |
| | Field Elements Subtotal | | | | $318,000 |
| | **REGIONAL TMC EQUIPMENT** | | | | |
| 8 | Regional Traffic Management Software/ server hardware/ licensing fees | 1 | LS | $175,000 | $175,000 |
| 9 | Additional (ATMS) software/ licensing fees for Region/Modules | 1 | LS | $75,000 | $75,000 |
| 10 | Enclosed Equipment Rack with UPS unit/ KVM | 2 | EA | $7,500 | $15,000 |
| 11 | TMC Work Station / ATMS Network Laptop | 7 | EA | $5,000 | $35,000 |
| 13 | LED Video Wall + Video Wall controller (3x2 Display Monitor) | 1 | LS | $85,000 | $85,000 |
| 14 | LED Video Display Monitor (60" LED) & wall mount - Public Wall Display | 1 | EA | $8,500 | $8,500 |
| 15 | Audio/Video Installation (Cabling, DVR, CATV, Lighting, Audio, Touch pad, Furniture) | 1 | LS | $120,000 | $120,000 |
| 16 | Fiber Distribution Unit & Fiber Termination | 2 | EA | $5,000 | $10,000 |
| 17 | Layer 3 Core Switch (upgraded spec) | 2 | EA | $20,000 | $40,000 |
| 18 | Firewall/ VPN Appliance (upgraded spec) | 2 | EA | $15,000 | $30,000 |
| 19 | Arterial Management System (Bluetooth/Wi-Fi) Software / Server | 1 | LS | $25,000 | $25,000 |
| 20 | Video Management System (VMS) Software / Share Server | 1 | LS | $75,000 | $75,000 |
| 21 | Changeable Message Sign (CMS) Software / Server | 1 | LS | $30,000 | $30,000 |
| 22 | Data Archive storage system | 1 | EA | $40,000 | $40,000 |
| 23 | ITS Asset Management Software platform | 1 | EA | $25,000 | $25,000 |
| 24 | Center-to-Center (C2C) Communication Platform (hardware/integration) | 1 | LS | $40,000 | $40,000 |
| 25 | Traffic & Transit Information Dissemination (Local 511) Platform | 1 | LS | $20,000 | $20,000 |
| 26 | Building Improvements (AC, HVAC, Plumbing, Electrical) | 1 | LS | $150,000 | $150,000 |
| | TMC Equipment Subtotal | | | | $998,500 |
| **CONSTRUCTION SUB-TOTAL :** | | | | | **$1,316,500** |
| Set-up and Mobilization (5% of construction cost) | | | | | $53,000 |
| Environmental Documentation (3% of construction cost) | | | | | $40,000 |
| Traffic Management Center Design/ Engineering (20% of construction cost) | | | | | $264,000 |
| System Integration (6% of construction cost) | | | | | $79,000 |
| Construction Management/ Administration (8% of construction cost) | | | | | $93,000 |
| Administration Fees (3% of construction cost) | | | | | $40,000 |
| On-site Testing & Training (LS) | | | | | $30,000 |
| **PROJECT SUPPORT SUB-TOTAL** | | | | | **$599,000** |
| CONTINGENCIES (15% of Total Construction Cost) | | | | | $198,000 |
| **TOTAL PROJECT COSTS:** | | | | | **$2,113,500** |

## Table 7.3. Sub-Regional DAC Infrastructure Cost

| Item No. | ITEM DESCRIPTION | Quantity | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|---|
| | **SUB-REGIONAL DAC EQUIPMENT** | | | | |
| 1 | ATMS software/ licensing fees per additional Intersection | 75 | EA | $1,250 | $93,750 |
| 2 | LED Video Wall + Video Wall controller (3x2 Display Monitor) | 1 | LS | $60,000 | $60,000 |
| 3 | Audio/Video Installation (Cabling, DVR, CATV, Lighting, Audio, Touch pad, Furniture) | 1 | LS | $60,000 | $60,000 |
| 4 | Layer 3 Core Switch (Configuration only) | 1 | EA | $10,000 | $10,000 |
| 5 | Firewall/ VPN Appliance (Configuration only) | 1 | EA | $10,000 | $10,000 |
| 6 | Video Management System (VMS) Software / CCTV Server | 1 | LS | $40,000 | $40,000 |
| 7 | Data Archive storage system | 1 | EA | $30,000 | $30,000 |
| 8 | ITS Asset Management Software platform | 1 | EA | $20,000 | $20,000 |
| 9 | Center-to-Center (C2C) Communication Platform (hardware/integration) | 1 | LS | $25,000 | $25,000 |
| | TMC Equipment Subtotal | | | | $348,750 |
| **CONSTRUCTION SUB-TOTAL :** | | | | | **$348,750** |
| Set-up and Mobilization (4% of construction cost) | | | | | $14,000 |
| Environmental Documentation (3% of construction cost) | | | | | $11,000 |
| Traffic Management Center Design/ Engineering (20% of construction cost) | | | | | $70,000 |
| System Integration (6% of construction cost) | | | | | $21,000 |
| Construction Management/ Administration (7% of construction cost) | | | | | $25,000 |
| Administration Fees (3% of construction cost) | | | | | $11,000 |
| **PROJECT SUPPORT SUB-TOTAL** | | | | | **$152,000** |
| CONTINGENCIES (15% of Total Construction Cost) | | | | | $53,000 |
| **TOTAL PROJECT COSTS:** | | | | | **$553,750** |
| | **SUB-REGIONAL DAC (East/ Central/ West Valley)** | **3** | **EA** | **$553,750** | **$1,661,250** |

The preliminary cost estimates provided above account for the necessary ITS hardware/software and A/V infrastructure required for a RTMC and a typical Sub-Regional DAC in the Coachella Valley. In addition, it includes the engineering design fees and integration costs typically associated with standard ATMS and ITS technologies for interior building improvements only. It does not take into account the physical location of the proposed RTMC building itself or the costs associated in procuring a dedicated space. Since the location of the RTMC building is not yet defined, a 1-mile radius is assumed for hardline connection to the proposed Highway 111 fiber optic system. This design approach is provided in further detail in *Chapter 6, Concept of Operations*.

## 7-10. CONCLUSION

The framework is provided for inter-agency coordination to provide a common structure for the planning, design, deployment, management, operations and maintenance of current and future Advanced Traffic Management Systems (ATMS), Intelligent Transportation Systems (ITS), and communication systems in the Coachella Valley. For inter-agency communication and coordination, the following items shall be adhered to across all agencies for consistency as mentioned previously in this chapter:

- Multi-Agency Participating Agreement
    - Responsibilities of Lead Agency
    - Responsibilities of Participating Agencies
    - Transportation Systems Management and Operations (TSM&O) Committee
- Standards Based Open Architecture / Inter-Operability
    - NTCIP / TMDD / IEEE Standards
    - COTS products
- C2C Platform / Inter-Connection of Systems
    - Fiber Optic P2P Links
    - Wireless Broadband
    - IPSEC VPN
- Hierarchal levels of Access / Roles & Responsibilities
    - Access Control Lists
    - End-User / Operator / Administrator

Overall, this Inter-Agency approach further applies to preparing the region for the future Connected and Automated Vehicles (CV/AV), Integrated Corridor Management (ICM), mobile applications, and SMART Cities integration.